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Analysis

Should We Be Wary of Mitigation Banking? Evidence Regarding the Risks Associated with this Wetland Offset Arrangement in Florida

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ABSTRACT

This paper describes and analyzes the risks associated with using mitigation banking for the conservation of wetlands in Florida in the United States. First, we attempt to identify and summarize the main ecological and socio-economic risks regarding mitigation banking that have been discussed in previous studies. Then we analyze the institutional responses adopted by US regulators to limit these risks. We have used empirical evidence including interviews and data analysis to assess the effectiveness of these responses. Our main findings are that the recent regulatory responses adopted to face risks associated with mitigation banking seem to be more effective than what is often assumed. These responses are underpinned by the emergence of a hybrid mode of governance that combines market characteristics and regulatory constraints, and which contributes to enforcing wetland compensation in Florida. However, we also observed some risks inherent in this system, in particular the redistribution of ecosystem services, as the distance between impact sites and compensation sites seems to have increased in Florida in the last several years. In addition, the question is still pending regarding whether or not No Net Loss of wetlands is really achieved through mitigation banking.

1. Introduction

In order to address current ecosystem losses, many countries legally require that developers follow a mitigation hierarchy that includes steps first to avoid, then to reduce, and lastly to offset any impacts on natural habitats. The aim of ecological offsetting is to allow development projects such as urbanization and infrastructure construction while ensuring No Net Loss of natural habitats through the ecological restoration of equivalent degraded natural habitat elsewhere. Today offsetting is required in many policies worldwide (Wilkinson and Thompson, 2006; Madsen et al., 2010; Maron et al., 2015). Wetlands have been subject to this policy tool for 40 years, both in the United States and in Europe (Hough and Robertson, 2009; Levrel et al., 2015; National Research Council, 2001; Quétier et al., 2014).

In the US, the mode of governance of implementing wetland offsets has significantly changed in the last few years, moving from a mainly permittee-based system to a mainly market-based system. The permittee system, known as Permittee-Responsible Mitigation (PRM), works on a case-by-case basis and requires that a developer compensate a project's impact on wetlands by restoring or enhancing a degraded natural wetland near the impacted area. In 2008, PRM represented 59% of the compensatory measures in the US, while by 2014 it represented 37.5% (Madsen et al., 2011; Institute for Water Resources, 2015). Several reports have shown that PRM lacks effectiveness in terms of ecological outcomes and have highlighted the high rate of non-compliance (Government Accountability Office, 2005; National Research Council, 2001). Mitigation banking (MB), created during the 1990s in the US, has been viewed as an innovative tool aimed at improving the efficacy of wetland offsets (Hough and Robertson, 2009). Essentially, MB involves a third party that anticipates the wetland offset needs of developers by carrying out large-scale restoration or enhancement of natural areas prior to any impact; these are known as 'mitigation banks'. The regulator assigns 'mitigation credits' to mitigation banks based on an assessment of the ecological gains made by the restoration project. These credits can then be exchanged in a 'service area' defined by the biophysical boundaries of a water basin. When developers need to compensate for an impact, they buy mitigation credits from the mitigation bank. In 2008, the Final Compensatory Mitigation Rule outlined

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the rules of the process in order to standardize the system at a national scale (USACE and EPA, 2008). This Final Rule document gave a preference to MB, leading to an increase in the use of this governance system from 35% in 2008 to 50% in 2014 (Madsen et al., 2011; Institute for Water Resources, 2015). Another system of governance is In-Lieu Fee (ILF) mitigation. This relies on a fund governed by a public agency or a non-profit organization. As with MB, the principle is to pool the offset needs of several projects; however, unlike MB, the compensatory measures are realized after the impact, when enough money is raised to implement the ILF management plan. The efficacy of ILF mitigation remains less clear at this stage than MB, as it represented only 6% of US compensatory measures in 2008 and 12.5% in 2014; it will not be discussed in this article.

The theoretical advantages of MB compared to PRM (National Research Council, 2001; Government Accountability Office, 2005; Hough and Robertson, 2009) are (1) better control by regulators of fewer stakeholders responsible for the success of compensatory measures, (2) that large-scale ecological restorations have a better chance of success than small, dispersed ones, and (3) that ecological gains would occur prior to any impact, protecting wetlands from temporal ecological losses, and ensuring that some ecological performance standards or milestones are met even if the offset project is not necessarily completed.

However, as many recent publications have noted, MB also carries risks. These risks are critical to assess in the context of the increasing development of MB in the US and the fact that this system is under discussion in Europe.[2] We identified eight categories of risks associated with MB that have been mentioned in studies:

- The risk of the privatization and commodification of wetlands, reflecting a neoliberal trend and a profound ethical change in conservation practices (Dauguet, 2015; Ives and Bekessy, 2015; Robertson, 2004; Spash, 2015).
- The risk of facilitating rather than limiting development projects (Walker et al., 2009).
- The risk of the homogenization of wetlands induced by market forces (Dauguet, 2015; Walker et al., 2009).
- The risk of the temporal loss of wetlands due to divergences in the timescale of the return on investment for a private firm and the timescale of restoration projects and the release of credits (Robertson and Hayden, 2008; Teresa, 2008).
- The risk of disconnection between impact sites and compensation sites, leading to a change in land-sharing dynamics and to spatial redistribution of the social and economic benefits delivered by wetlands (BenDor et al., 2007; BenDor and Riggsbee, 2011; Ruhl and Salzman, 2006).
- The risk of a lack of long-term management and of bankruptcy (Gardner, 2012; Gardner and Radwan, 2005; Robertson, 2008).
- The risk of reversing the ends and the means: protecting the market rather than the environment (BenDor and Riggsbee, 2011; Gordon et al., 2015; Walker et al., 2009).
- The risk of reversing the ends and the means: using the money generated by offsets to achieve previously agreed conservation targets (Maron et al., 2015; BenDor and Riggsbee, 2011; Gordon et al., 2015; Walker et al., 2009).

To our knowledge, few articles have attempted to provide an overview of the ecological and socio-economic risks of mitigation banking. Two articles have discussed the strengths and weaknesses of MB (Bekessy et al., 2010; Walker et al., 2009), but these were based on a review of the existing literature and on theoretical assumptions. Our study goes further in the analysis of these risks, using various sources of information such as quantitative analysis and interviews.

We conducted an institutional analysis of regulatory tools to determine their effectiveness in controlling the different types of risks arising from MB, using interviews carried out in the US Army Corps of Engineers (USACE) Jacksonville District (whose area of responsibility encompasses the state of Florida), literature review, data collection (from data available on US environmental institution websites) and statistical analysis. This enabled us to distinguish between risks that are addressed by specific regulatory responses and risks that remain to be addressed. We also found that some of the risks cited in previous articles concern the very principle of offsetting rather than MB per se, even if the study intended to specifically address mitigation banking.

The article is organized as follows. Section 2 presents the materials and methods used in this study. Section 3 presents the results and discusses the eight categories of risks mentioned above, the regulatory solutions adopted to limit these risks, and the effectiveness of these measures. The final section concludes by outlining the remaining risks of MB that should be taken into account.

2. Material and Methods

This study is based on a review of existing literature, quantitative analysis, and interviews carried out in Florida (the USACE Jacksonville District). The quantitative analysis was carried out using various information sources. The first was data from the Regulatory In-Lieu Fee and Bank Information Tracking System (RIBITS, 2016), a publicly available database that includes several kinds of information on the mitigation banks in a given area, such as the number of transactions, the credit classifications used, the bank type, and the number of credits released and sold. This data was extracted for treatment in July of 2016. We also used data from the National Land Cover Database (Fry et al., 2011; NLCD, 2011) on changes in land cover for the years 2001, 2006 and 2011, which enabled us to assess the surface areas of wetlands and urbanized areas and how these have evolved in Florida. Another source of data was USACE's ORM Permit Decisions database (USACE, 2016), which details all the permit requests for wetland impacts, and from which we extracted data between 2008 and 2016. Spatial analysis was carried out with the ArcGIS tool. Statistical analyses were carried out using Microsoft Excel. The main goal of this data collection was to obtain a broad picture of the situation regarding mitigation banking in the US. Combining the data from the RIBITS and ORM databases for the Jacksonville District, we calculated the mean distance between the centroids of active and inactive (sold-out) mitigation banks and their associated impacts for the 2008–2016 period. We also sought to provide a quantitative description of the MB system in the Jacksonville District in order to compare this district with the rest of the US.

The collected data was complemented by interviews carried out in Florida in 2013. We conducted 54 face-to-face semi-structured interviews in visits to 20 mitigation banks, collecting information on 71 of the 91 approved or pending banks in the Jacksonville District at the time the interviews were held (see Appendix A). All categories of MB stakeholders were interviewed: environmental consultants ($n = 20$), landowners, managers/operators of mitigation banks ($n = 28$), regulators[3] ($n = 7$), brokers of mitigation credits ($n = 4$) and other professions (e.g. lawyers, academics, NGOs, developers/bank clients $n = 6$). One individual could hold several roles. For instance, an environmental consultant might be hired as a mitigation bank manager. The main goal

[2] Germany, for example, has used compensation pools since the early 2000s (Wende et al., 2005). In France, a new biodiversity law voted in 2016 introduced habitat banking, following the creation of several pilot banks.

[3] These included regulators from the Florida Department of Environmental Protection (FDEP), the permitting team and the mitigation banking team of the United States Army Corps of Engineers (USACE) Jacksonville District, the South Florida Ecological Services Office of the United States Fish and Wildlife Service (USFWS), several Water Management Districts (WMD) and several counties.

of these interviews was to obtain a complete picture of the system and how it works in a specific context and while in operation. The interview outline on which we based our discussion with respondents is provided in Appendix B.

To determine whether the RIBITS database was reliable enough to support an analysis of mitigation banks, we compared the data collected during our interviews with data extracted from the RIBITS database. The database for the Jacksonville District can be considered homogeneous, since a single USACE agent was responsible for maintaining the database for wetlands banks (at least until 2013). The interviewees validated the number of transactions and credits sold, suggesting that these indicators were sound. However, interviewees reported that the types of conservation action mentioned for their bank (e.g. preservation, restoration or rehabilitation) were not always correct, mainly because each bank encompasses multiple types of actions, while the database mentions only the main action carried out. We also noted that the RIBITS information on the type of bank was sometimes incorrect: out of 60 banks in the district indicated as 'private–commercial', at least 11 were in reality a 'public–private partnership' or 'public–commercial' banks. Nonetheless, 74% of respondents said that the database is useful in terms of the transparency of the regulation system. We considered that the quality of the RIBITS database for the Jacksonville District was good enough to conduct our analysis.

3. Results and Discussion

Table 1 summarizes our main findings, which are discussed in detail this section.

3.1. Does Mitigation Banking Lead to the Privatization and Commodification of Wetlands and a Move toward a Utilitarian Ethic?

It is often claimed that MB leads to the privatization and commodification of natural habitats (Dauguet, 2015; Ives and Bekessy, 2015; Robertson, 2004). An investigation of what has occurred in reality demonstrates that there are at least three reasons why MB is not a source of privatization of a public good. The first is that the land on which the impact and the compensation occur is often already private. Second, public agencies can buy private land to create mitigation banks and sell mitigation credits (Table 2). Third, the creation of a mitigation bank requires adopting a conservation easement on the land acquired for compensation. This easement removes, in perpetuity, the right of the private owner to develop the land and applies to the current and any future owner. The result is that the property rights largely move into the public domain.

Concerning commodification, many mitigation banks in Florida have been created on land already commodified, such as agricultural land devoted to cattle farming or silviculture. The ecological lift provided by the restoration actions represents the 'mitigation credit', not the restored habitat itself. Commodification of wetlands occurs when compensation credits are gained by preserving lands that are already dedicated to wetland protection. Moreover, MB conservation actions are aimed at the acquisition and protection of threatened private land that would have been damaged without human intervention.

Some recent articles have shown that MB is a hybrid regulation system that combines market and regulatory characteristics (Vaissière and Levrel, 2015; Fig. 1), and not a conventional market as is often claimed (Bayon and Jenkins, 2010; Walker et al., 2009; Spash, 2015). MB is

Table 1
Summary of the potential risks of mitigation banking, the regulatory responses to these risks, and the efficacy of these responses.

Risks	Regulatory responses	Effectiveness of the response
Privatization, commodification of nature and a move toward a utilitarian ethic	Conservation easement	Private rights move into the public sphere since the owner of the land is deprived of the right to use it
	Compensation mostly restricted to private lands where former production was oriented toward market goals	Commodification of an ecological lift rather than of nature itself
	In Florida, mitigation banks cannot be created on public land already purchased for conservation reasons	Hybrid system more than a strictly market-oriented system Utilitarian ethic behind offsetting is questionable
Facilitation of development projects with impacts on wetlands	Compensation occurs at the end of the mitigation process	No evidence of an increase in authorization for impacts on wetlands as measured by changes in the ratio of agreements to the total authorization demands
	Increase in ecological requirements	Evidence that the goal of No Net Loss (in surface area) is not achieved through MB
Homogenization of wetlands due to market forces	Priority given to restoration actions	69% of compensation credits in MB are based on restoration actions (42% in PRM) (source: RIBITS)
	Diversification of credit classifications	98% of the legal ecological performance requirements are reached
	A given type of credit can only be exchanged within the service area of the mitigation bank	No evidence that 'real' ecological performance is reached
Temporal loss of wetlands	Credits are released for sale in 4 to 5 stages in which ecological objectives are monitored	In Florida, the 12 mitigation banks that have had all their credits released received them in 8.8 years on average
	Monitoring for at least 5 years	The number of credits sold is lower than the number of credits released over a period of 20 years (net ecological gain)
Spatial disconnection of impact and compensation sites	The market size for one bank is limited to a service area corresponding to a sub-basin watershed	Mean distance between the compensation site and the impact site is 37.3 km in Florida (this distance is increasing in Florida)
Replacement of previously agreed conservation policies	In Florida, private–public agreements to create mitigation banks are not allowed if the land has already been acquired by public agencies for a conservation purpose	The majority of mitigation banks are created on private land with private funds
A simple right to destroy	The right to destroy is constrained by a strong regulatory policy	Decreasing loss of wetlands at the national scale (16,000 ha/year now vs. 135,000 ha/year in the 1980s), but still a net loss
	Institutional innovation to create a high-quality market (high level of enforcement, harmonization of the method of calculation, open-access database on credit transactions and credit descriptions with RIBITS, etc.)	No increase in authorizations for impacts on wetlands Decrease in the surface area of wetlands in the service areas during the survey period Increase in the price of compensation credits tends to discourage destruction and encourages developers to avoid and reduce impacts before compensation; the creation of a mitigation bank may even change the status of the private land (from an urbanization to an environmental trajectory)
Risk of a lack of long-term management or of bankruptcy	Conservation easement	Some evidence that the insurance and long-term funds work well
	Requirement for insurance and a long-term management fund	Some evidence that the long-term management funds are insufficient

Table 2
The different types of wetland mitigation banks in the US.

Type of mitigation bank	Number of banks
Single-client	304
Combination public/private	23
Private non profit	19
Public commercial	87
Private commercial	979
Total	1412

Source: RIBITS (2016).

primarily a tool for implementing public environmental policy based on environmental standards (the No Net Loss principle). The market is far from free – it is a regulated market in which the regulator plays a key role by validating each transaction in a specific territory (the service area) and 'shaping' the demand based on ecological criteria. It is impossible to develop a derivative market from the offset credits created by investing in a mitigation bank project. Compensation credits can be purchased only by a developer and only for the impact of a project in the context of a permit application. It is not possible for speculation to occur in this context.

However, even if offsetting is based on a publicly regulated permit system, some authors argue that this system leads to the transformation of natural habitats into commodities by the simple possibility of substitution (Dauguet, 2015; Walker et al., 2009). These authors assert that this represents a move from conservation ethics toward utilitarian ethics in conservation practices (Ives and Bekessy, 2015). This point is questionable, as it seems based on confusing 'equivalency', 'commensuration' and 'commodification'. Commensuration and equivalency (fungibility) are a prior condition for commodifying some natural entities, but they are not identical to commodification per se. Commodification is intrinsically associated with the capitalist system, while many non-capitalist societies have considered natural entities as equivalent and subject to exchange (i.e. fungible). For instance, see the examples of a 'gift-exchange economy' described by Marcel Mauss decades ago (Mauss, 1924). Moreover, some authors confuse commodification and marketization (the creation of a 'real' market) as underlined by Noel Castree (2008, 2010). This confusion has been used to demonstrate that markets regarding ecosystems are now increasing, in order to support (Bayon and Jenkins, 2010) or to criticize this trend (Spash, 2015).

Taking these points into consideration, the idea that MB results in the privatization and commodification of wetlands seems to be a theoretical view not supported by empirical evidence. As we have demonstrated, MB is a largely hybrid and highly regulated system, yet it is still sometimes perceived as a form of 'nature commodification'. This commodification may be symbolic—implied by the use of terms and concepts such as 'banks', 'credits' and 'markets'. This use of 'market language' suggests commodification, and can reflect a wish to contrast the private and public sector to demonstrate that markets are more (or less) effective than public regulation in implementing environmental policy, and to discredit (or reinforce) public institutions in comparison with private institutions. The private MB lobby, the National Mitigation Banking Association (NMBA), and other supporters of MB voluntarily adopt this strategy in some political contexts (BenDor et al., 2015). Some authors argue that because certain political ideologies may be more likely to support 'market-based' approaches to environmental conservation as opposed to 'regulatory' or 'command-and-control' approaches, MB risks being a source of symbolic manipulation that should not be underestimated, especially for ethical reasons (Ives and Bekessy, 2015).

Yet even from an ethical point of view, whether or not wetland offsetting is inspired by utilitarian philosophy is an open question. Of course, offsetting is intrinsically linked to the concepts of equivalency and substitution. However, the principle of environmental offsetting reflects a move from welfare equivalency (a utilitarian approach with weak sustainability criteria) toward ecological equivalency (an ecological approach with strong sustainability criteria) (Pearce and Atkinson, 1993; Ekins, 2003; Vaissière et al., in press). To understand this historical change, it is important to remember that the compensation principle was initially considered from the perspective of 'social welfare' (corresponding to a given area's maximum utility for a targeted population), legitimizing the destruction of some natural elements (natural capital) when these were outweighed by the economic growth resulting from an increase in physical capital. This was based on the Kaldor-Hicks efficiency criterion (Hicks, 1939; Kaldor, 1939). Applied to projects impacting wetlands, this led to the position that a natural ecosystem was substitutable with physical capital once it created economic wealth, and that it was possible to compensate people affected by these impacts. Indeed, this compensation principle focused solely on impacts on people. Monetary compensation for economic (or well-being) losses arising from the destruction of natural areas was the most common form of compensation during the last two centuries (Fressoz, 2013). So the contemporary concept of environmental compensation, which requires that any impact on wetlands must be compensated in biophysical units, can be considered as a move away from utilitarian philosophy and toward a conservationist philosophy.

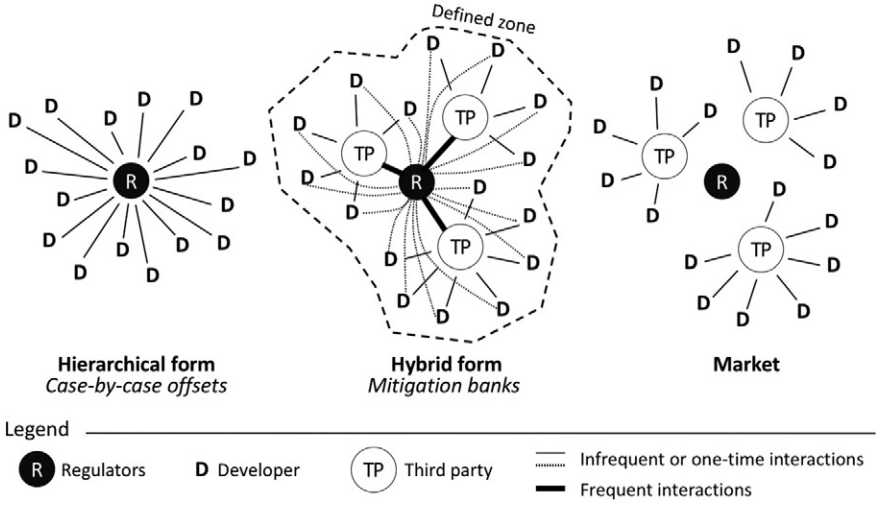

Fig. 1. Wetland mitigation banking as a hybrid organizational form.

3.2. Does Mitigation Banking Facilitate Development Projects?

The risk of facilitating development projects is linked, first of all, to the very principle of offsetting. It could be considered that the use of MB further facilitates the offsetting procedure for developers, since it may be easier to buy credits than to find land available for restoration close to an impact site in order to carry out a restoration project (Walker et al., 2009). Some argue that MB could additionally encourage developers to compensate for their impacts rather than avoiding and reducing these in the first place. We will not discuss the compensation principle here, but focus on the specific risks associated with MB.

The concern that MB might facilitate the offsetting procedure is not supported by the data. It is true that the number of compensation measures carried out through mitigation banks has increased in recent years: they are a new offset solution, and regulators gave preference to mitigation banks in the 2008 Final Rule (Fig. 2). In 2008, the proportional breakdown of the different types of compensation methods was: 35% for MB, 59% for PRM, and 6% for ILF (Madsen et al., 2011). In 2014, the proportions were 50% for MB, 37.5% for PRM, and 12.5% for ILF (Institute for Water Resources, 2015).

However, the number of development permits did not rise between 2008 and 2015, and the rate of refusal did not significantly change (2.6% in 2009; 2.4% in 2010; 1.2% in 2011; 1.8% in 2012; 1.6% in 2013; 1.4% in 2014; 1.2% in 2015; Fig. 3). So it seems the MB does not facilitate the offsetting procedure and the development projects.

In terms of the risk of MB undermining the avoidance and reduction steps of the mitigation hierarchy, this is complex to assess. These steps are the result of specific negotiations between local regulators and developers, making it difficult to generalize about them; the question of their effectiveness is more closely linked to the broader compensation principle than specifically to MB. However, we can safely assume that if avoidance and reduction steps had been replaced by compensation actions, the demand for development permits would have increased; but as mentioned above, this does not seem to be the case.

In addition, it can be assumed that the cost of compensation serves as an incentive to avoid and reduce impacts as much as possible in order to save money. For example, the price of mitigation bank credits in New Jersey is around USD $400,000 per credit (1 credit corresponds to a mean of 1.6 ha) and between USD $25,000–$200,000 per credit (1 credit corresponds to a mean of 1.3 ha) in Florida (Hassan et al., 2015, p. 158).

However, if we look at the final outcomes in terms of the surface area of wetland loss in Florida, our initial results need to be qualified. In Florida, between 2001 and 2011, MB restored 58,575 ha. However, the decrease in wetlands over this period was 5600 ha per year, corresponding to a loss of 1.05% of the wetlands in this state (from the surface area of wetlands in 2001). On the national scale, Dahl (2011) estimated a decrease in wetlands of 16,000 ha per year between 2004 and 2009.

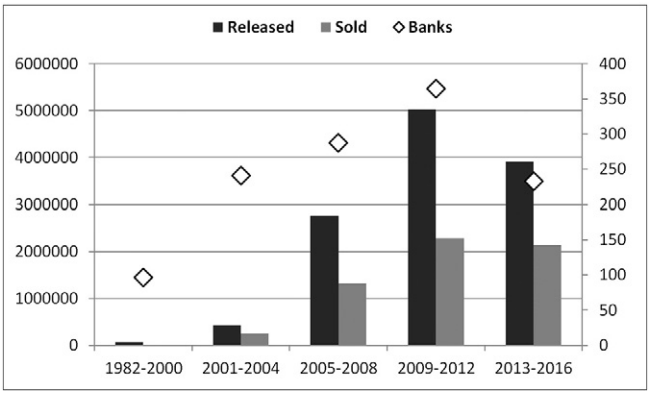

Fig. 2. Number of released credits, sold credits and wetland mitigation banks (RIBITS, 2016).

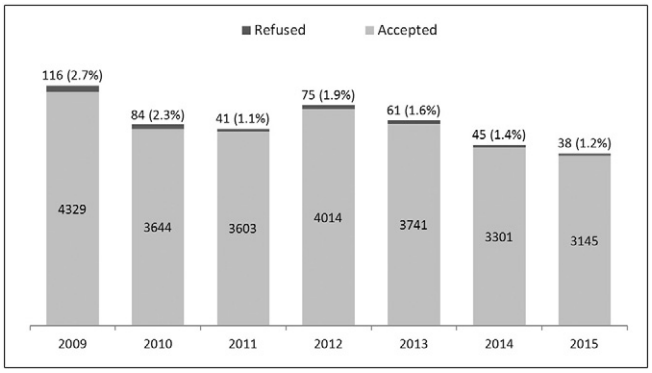

Fig. 3. Number of wetland destruction permits accepted and refused from 2009 to 2015 (USACE, 2016).

These authors considered this a positive trend compared to the estimated decrease of 134,000 ha per year between 1974 and 1984 (Dahl, 2011). They put forward that this positive trend is the result of recent environmental policies regarding wetland protection, including mitigation policies. Nevertheless, wetland losses are still far from the goal of No Net Loss.

To specifically investigate the role of MB in wetlands lost to development, it is essential to know if the loss in MB service areas is more or less than in other areas (61% of the surface area of Florida is covered by a service area where one or several mitigation banks are active). In these service areas, the estimated total loss of wetlands between 2001 and 2011 was 4700 ha per year, i.e. 1.26% of the wetlands (from the surface area of these service areas in 2001). These numbers seem to indicate that wetland destruction is higher in mitigation bank service areas—sites where compensation should theoretically be more effective and closer to No Net Loss. This may be because the mitigation banks are located where the rate of wetland destruction is higher. Indeed, the evolution of urban coverage between 2001 and 2011 is 13,000 ha in Florida (+6.41%) and 11,200 ha in service areas alone (+7.04%). Nonetheless, the evidence seems to point to the fact that the No Net Loss goal is less respected in areas where MB is operating than elsewhere, though it is difficult to draw a definitive conclusion regarding the role of MB. Scientific studies and national monitoring are still insufficient for a thorough discussion on the achievement of the goal of No Net Loss of wetlands and the respective roles of the compensation options (MB, PRM and ILF). As PRM and ILF are also used within the perimeter of service areas, it is difficult to isolate the role of MB in the net evolution of wetland surface area. Another obstacle is that the studied period of time includes pre-2008 data (before the widespread implementation of MB following the adoption of the Final Rule) and stops in 2011, which is a bit soon to measure any effects due to institutional resiliency. Few mitigation banks existed at the beginning of the study period – most were created near the end of the period. Lastly, it should theoretically be possible to have No Net Loss in terms of ecological function even with a net loss of surface area; however, this would result in a surface ratio lower than 1:1, which is not very convincing for a goal of No Net Loss, especially if retaining at least the same surface area is considered necessary for maintaining the habitat of specific species.

Another source of concern is that a recent work questions the validity of wetland reporting carried out at the national scale, such as that used in the study by Dahl (2011). It seems that the methods used to assess the ecological gains resulting from wetland restoration projects lead to a significant overestimation of these gains (Griffin and Dahl, 2016). In their recent study, the authors state that the actual reestablished wetland area in the state of Wisconsin was 61% less than what was estimated in official reports. This inaccuracy is also likely to be true for Florida.

The main conclusion at this stage is that MB does not seem to facilitate development projects, but the question of whether or not it

increases the likelihood of reaching the goal of No Net Loss of wetlands is still pending.

3.3. Does Mitigation Banking Risk Homogenizing Wetlands through Market Mechanisms?

3.3.1. Ecological Risk

To make transactions easier, markets need to exchange the simplest and most homogeneous units possible. This is a basic rule so supply and demand can be matched. The more complex and diverse the units of exchange, the more they act as a source of constraint for the market (Vaissière and Levrel, 2015; Scemama and Levrel, 2014). Within the context of MB, numerous types of wetland mitigation credits would decrease the possibility of finding matches between the developer, who must find a type of credit corresponding to the impact to be compensated, and the mitigation bank, which must sell a type of credit that has been released for the restoration of specific wetlands. One strategy of stakeholders might be to broaden ecological equivalence in order to increase market size. For instance, the purchase of palustrine emergent credits might be permitted to compensate for impacts on estuaries. Such a dynamic could lead to a severe reduction in the complexity and diversity of aquatic ecosystems (Dauguet, 2015; Walker et al., 2009).

3.3.2. Regulatory Responses

In the US, the USACE has adopted several methods to limit the effects of such homogenizing strategies. First, this regulator has created different types of credits, each corresponding to a specific market. For example, in Florida, the USACE uses 8 types of credit classifications for wetlands: the most common types are *estuarine*, *palustrine*, *palustrine emergent* and *palustrine forested*, less common are *palustrine scrub/shrub, palustrine open water, estuarine intertidal emergent* and *estuarine intertidal forested*. The USACE also requires that mitigation credits be exchanged within the service area of the mitigation bank that sells them (see Section 3.5). For instance, a developer impacting estuarine habitats in the Everglades (southern Florida) would not be allowed to buy estuarine credits from a mitigation bank in the Panhandle (northwestern Florida).

In addition, regulators have developed standardized methods for calculating mitigation credits. Based on ecological function, these methods allow a more objective comparison of the ecological losses from impacts with the ecological gains from restoration actions. The credits are thus linked to the actual ecological lift and harm. To reach ecological equivalence, the same method must be used to calculate both the mitigation credits that must be bought, and the credits released to the mitigation bank. For example, in Florida, local regulators developed the Uniform Mitigation Assessment Method (UMAM), which has gradually become the most commonly used calculation method both by the Florida Department of Environmental Protection (FDEP) and the USACE. Although it is not mandatory, mitigation bankers now prefer to use this method as the demand for credits is typically expressed in UMAM credits. The UMAM evaluates ecological function using several types of indicators: ecological community structure, hydrologic connection, ecosystem uniqueness, location, fish and wildlife utilization, time lag, and mitigation risk.

3.3.3. Efficacy of Regulatory Responses

At the national scale, it appears that the number of credit types has greatly increased (Fig. 4). This can be considered as a proxy for the way the diversity of wetlands is taken into account in the calculation of equivalencies. With regard to this indicator, there is no evidence that the development of MB (Fig. 2) leads to homogenization in the types of wetland credits (Fig. 4).

In addition, priority is given to restoration actions (the best way for offsetting impacts). Indeed, 69% of compensation credits in MB are based on restoration actions (42% in PRM) (Table 3)

To further explore the issue of homogenization, it is important to look at the quality of the restored wetlands in mitigation banks. A first point in favor of MB is the size of the projects. In a recent ambitious review of wetland restoration projects, Moreno-Mateos et al. (2012) highlighted that the size of a restoration project is one of the most important criteria in the success of a wetland restoration action, concluding that for surface areas of more than 100 ha, the chance of success was around 100%. The main characteristic of mitigation banks is specifically to pool together small compensation projects to create massive restoration actions. In the US, the average size of a mitigation bank is 195 ha—41% have more than 100 ha (RIBITS, 2016). This is one of the major strengths of MB, which results in the creation of larger restoration projects than PRM. In Florida, the mean size of a mitigation bank in 2013 was 800 ha (ranging from 23 to 9800 ha).

Regarding ecological performance as defined by the US Government, the results of MB appear to be good. According to a recent study, 98.7% of mitigation banks comply with the government's ecological performance criteria (Denisoff and Urban, 2012). However, this rate may be based on benchmarks that are insufficient from an ecological point of view, which would imply that a definition of No Net Loss would be questionable.

Unfortunately, if we want to go further in assessing the ecological performance of MB, ecological monitoring is often missing. Very few studies have done an in-depth ecological analysis of mitigation banks based on fieldwork. One that has often been cited to argue that MB leads to deterioration in the quality of wetlands was a study by Mack and Micacchion (2006) (Murphy et al., 2009; Walker et al., 2009). This remains the only exhaustive analysis regarding the monitoring of mitigation banks (in this case 12 mitigation banks in Ohio). It found that 25% of the area managed by mitigation banks could not be considered as

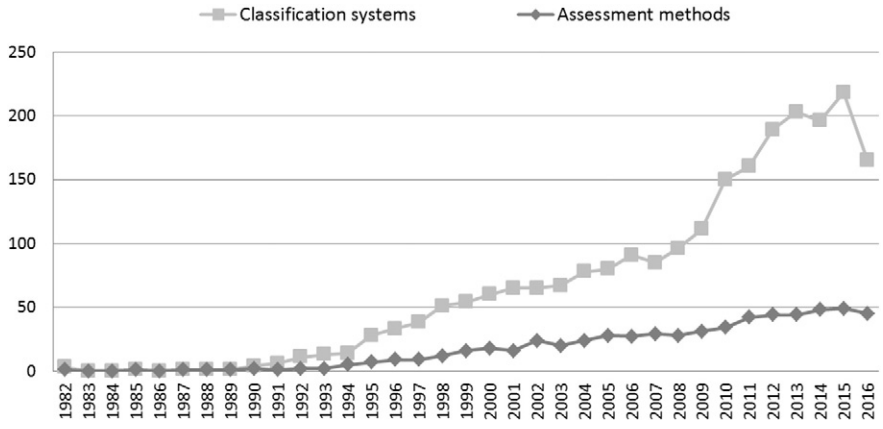

Fig. 4. Number of types of credit classification and of methods of assessment (RIBITS, 2016).

Table 3
Types of compensation actions implemented by wetland mitigation banks in the US.

Compensation action	Number of banks
Unspecified	206
Specified	1180
Preservation	93
Preservation of buffer zone	22
Enhancement	164
Rehabilitation	160
Re-establishment	642
Creation	99

Source: RIBITS (2016).

wetlands. Of the 75% of the MB area that could be considered wetlands, 18% were of good quality, 58% were of moderate quality, and 24% were of low quality. The seeming conclusion is that these mitigation banks failed to restore wetlands. However, one important limitation of this study is that it does not consider the age of the mitigation banks. As mentioned in several studies by Robertson and Hayden (2008), it takes at least four years for a mitigation bank to meet its ecological potential. Moreover, it takes 10–20 years to observe the full ecological response of wetlands to restoration actions (Jones and Schmitz, 2009), and even longer for some specific ecological functions (Moreno-Mateos et al., 2012). Of the 12 banks that Mack and Micacchion evaluated, 6 were less than 4 years old and had not yet received all their credits corresponding to ecological outputs (see next section). So the findings of these authors can be considered incomplete since the study was carried out before the end of the restoration process and the release of the corresponding credits. This assumption is strengthened by the work of Spieles et al. (2006), who monitored the two oldest mitigation banks (created in 1993 and 1994) studied in the Mack and Micacchion sample. Their study showed a high degree of similarity between these two mitigation banks and natural wetlands. One clear conclusion from these works is that it takes time to see the results of restoration in a mitigation bank. Furthermore, these studies were carried out 10 years ago, and the context has changed since the publication of the Final Rule in 2008.

3.4. Does Mitigation Banking Cause Temporal Loss of Wetlands?

3.4.1. Ecological Risk

The management plan of a mitigation bank involves the implementation of ecological restoration measures, but many years are required to achieve the ecological goals and hence to be allowed to sell mitigation credits. This is not compatible with the timescale for return on investment that private firms expect. In other words, for a project to be economically viable, a mitigation banker wants to minimize the duration between its initial investment to the selling of the first credits. This is why a mitigation bank has some mitigation credits released by the regulators prior to any ecological lift. This makes sense from an economic point of view, but could lead to a temporal loss of wetlands (Robertson and Hayden, 2008).

3.4.2. Regulatory Responses

The temporal trade-off between the economic viability and the ecological efficacy of MB works as follows. First, the adoption of conservation easements serves to ensure a long-term approach to the compensation project. Second, the credit release schedule enables the regulator to control both the risk of temporal loss and the quality of the restoration work by the mitigation bank. A mitigation banker never receives all the potential credits at the outset. The credits are usually released in three main stages:

- Administrative credits are released after the acquisition of the compensation site, the adoption of a conservation easement, the approval of the restoration management plan by several government agencies, and the creation of an insurance fund and a long-term management fund.
- Works and planting credits are released when monitoring has revealed that the required hydrological work and planting have been carried out.
- Ecological success credits are gradually released when ecological success criteria (e.g. the restoration of the native plant population or of certain levels of abundance and richness of local species as well as floristic quality indices) are reached.

If one of these stages is not completed, the credits are not released, nor are those of the subsequent stages. Moreover, the released credits may be 'frozen', which means they cannot be sold until the mitigation banker has remedied the situation. Each state or district may adapt this schedule to local conditions; in addition, each schedule is adapted to the specific mitigation bank (BenDor et al., 2011).

In the US, ecological monitoring of the site must take place for at least 5 years (Final Rule, Section 230.96) and must be adapted to the specific wetland dynamics. After 5 years, certain basic indicators must be met: 85% survival rate for target species, less than 15% of invasive species, etc.

3.4.3. Efficacy of Regulatory Responses

The 71 approved wetland mitigation banks of the Jacksonville District have had 65% of their credits released on average (RIBITS, 2015). Fig. 5 shows the distribution of percentages of released mitigation credits in the Jacksonville District. More than one-third of mitigation banks in Florida have had more than 80% of mitigation credits released. These are in their final stage, waiting for their ecological success credits to be released.

The 12 mitigation banks that have had all their credits released received them in 8.8 years on average (ranging from 2.3 years to 13.7 years, $SD = 3.4$). Of these, the 5 mitigation banks for which full information on each credit release stage is available, the full release of credits was reached in 8.2 years on average (ranging from 4.5 to 10 years, $SD = 2.2$); the distribution is detailed in Table 4.

BenDor et al. (2011) found that in the US as a whole, the average released administrative credits for wetland mitigation (without ecological results) was 36.7%. In Florida it is around 26%.

Given that the timescale of ecological response to wetland restoration is between 10 and 20 years (Jones and Schmitz, 2009; Moreno-Mateos et al., 2012), while the release of wetland credits can take between 5 and 15 years (8.8 years in Florida) depending on the district (Robertson and Hayden, 2008; BenDor et al., 2011), the risk of temporal loss is a real concern on a case-by-case basis. However, Fig. 2 also shows that the number of released credits is always higher than the number of sold credits, suggesting that there can be—at least as regards

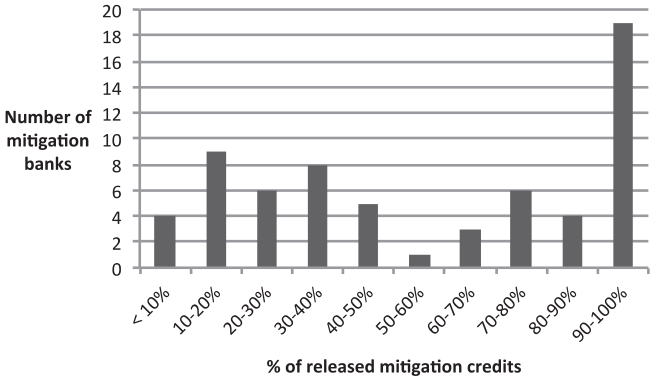

Fig. 5. Distribution of mitigation banks per category of the percentage of released mitigation credits (RIBITS, 2015).

Table 4
Distribution of credits according to the main stages of the credit release schedule in Florida.

	Administrative credits	Works and planting credits	Success credits
% of the total potential credits	26% [min = 13; max = 60] *SD* = 20	37% [min = 10; max = 67] *SD* = 27	37% [min = 10; max = 70] *SD* = 25
Number of years to reach the full release of credits for each stage of the credit release schedule	1.6 years [min = 0; max = 6.1] *SD* = 2.5	2.2 years [min = 0; max = 4.1] *SD* = 1.7	4.4 years [min = 1.3; max = 9.3] *SD* = 3

surface area—some temporal gains of wetlands through MB as a whole. The final net effect is difficult to assess. But during the most recent period of our study (2008–2013), it seems clear that more than one-third of the released credits have not been sold. This approximates the rate of released administrative credits (without ecological gains).

3.5. Does Mitigation Banking Promote Disconnection between the Impact Site and the Restoration Site?

3.5.1. Ecological and Social Risks

One of the main concerns about wetland mitigation banks is that they might result in ecological restoration in remote sites, far from the impacts they are meant to compensate, thus reflecting a spatial substitution of aquatic ecosystems (Ruhl and Salzman, 2006). This is due to the fact that mitigation banks would be encouraged to make investments where the cost of land is low, leading to a concentration of impacts in urban areas and a concentration of compensation in rural areas, a phenomenon known as 'land sparing' and resulting in a clear separation between conservation-based zones and production-oriented zones. This spatial specialization poses the risk of creating a green belt away from cities, an outcome that raises ethical and social issues concerning access to ecosystem services (BenDor et al., 2007; BenDor and Riggsbee, 2011; Ruhl and Salzman, 2006).

3.5.2. Regulatory Responses

The risk of increasing the distance between the impact site and the compensation site is taken into account through the creation of service areas that correspond to the size of the market in which offset credits can be exchanged (BenDor et al., 2011; Robertson and Hayden, 2008; Vaissière and Levrel, 2015). In the US, a wetland service area is usually defined on a sub-watershed basis, corresponding to approximately 1800 km^2 (Hydrologic Unit Code 8). However, each district has autonomy regarding the definition of these service areas, and the regulator can add administrative, demographic or economic constraints to these boundaries. In any case, the mitigation bank site must be located in a place where connectivity with natural wetlands has been demonstrated, which means that the restoration project cannot be completely isolated from these. The regulator uses a system of compensatory ratios to modulate the calculation of equivalence and of offset credits based on other criteria in order to drive investment in wetland restoration projects toward the places where ecological threats are most significant.

Another tool created by the USACE is the online database RIBITS, which allows anyone to locate the mitigation banks. By correlating this database with the ORM Permit Decision Database, it is possible to geo-locate impact and compensation sites. This shows the distance between the mitigation banks and the impacts for which their credits could be used, enabling environmental NGOs to quickly assess the ecological coherence between the impacted zone and the restored zone on a case-by-case basis.

3.5.3. Efficacy of Regulatory Responses

Mitigation banking is necessarily an 'off-site system' since it is based on the principle of pooling together small compensation sites that are usually 'on-site' in PRM. As a result, spatial disconnection is always higher with MB than with PRM. However, one large restoration project has a better chance of success than a multitude of small ones (Moreno-Mateos et al., 2012). Thus, there is a trade-off between the chance of success and the spatial disconnection induced by MB.

In the US, the mean size of a service area is around 1500 km^2 (BenDor et al., 2011). In Florida, the mean size is around 3800 km^2 (RIBITS, 2016). Service areas in Florida have a larger mean surface area because the topography in southern Florida is very flat. As mentioned above, mitigation banks themselves are also bigger in Florida. The map of the service areas and mitigation banks we studied in 2013 (Fig. 6) shows that regulators voluntarily decreased the size of some service areas in southern Florida in order to avoid too much distance between impact and restoration sites.

Concerning distances between the site of impact and the site of compensation, Ruhl and Salzman (2006) have shown that in Florida, impacts tend to be located in urban areas, while compensation sites tend to be located in rural areas, with migration of wetland resources to less densely populated areas. That shift was apparent for 19 of the 24 banks in their study. However, BenDor et al. (2007) found that this relocation of wetlands away from urban areas also occurred for ILF and PRM off-site projects. Maps locating the ecological gains associated with mitigation banks and the loss of wetlands associated with impacts seem to suggest that MB does not generate a concentration of impacts in urban areas and of restoration in the countryside (BenDor and Stewart, 2011).

For the 2008–2016 study period in the Jacksonville District, based on the information available for 54 banks and representing 437 transactions (i.e. sales of credits for all or part of an impact), the average distance

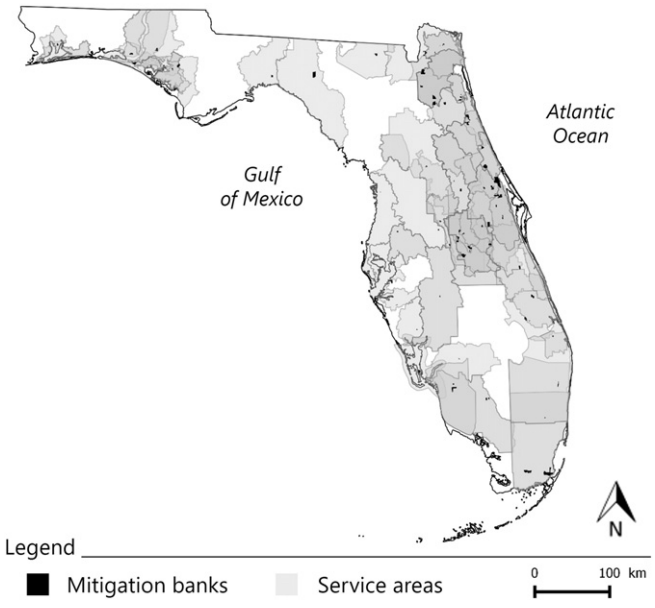

Fig. 6. Map of the mitigation banks and their service areas studied in 2013 in the district of Jacksonville. Source: Shapes of the mitigation banks and their service areas available on the Florida Department of Environmental Protection website (FDEP, 2014).

between a bank and its associated impacts was 37.3 km (SD = 26.6 km) with a median of 30.9 km (ranging from 1.8 km to 221.7 km).

The interviews we carried out in Florida revealed that the choice of land by mitigation banks was not only guided by the price of the land, but also by a variety of other criteria. These included the potential ecological lift resulting from the restoration project; the size of the site; and the location (e.g. near an area of urban expansion or within a service area where there are no other banks, i.e. where mitigation bankers benefit from a monopoly) (BenDor and Riggsbee, 2011; Robertson, 2008; Vaissière and Levrel, 2015). The interviews also revealed that in certain situations, and contrary to what is often assumed, mitigation bankers and developers compete for land. The added value generated by mitigation banks in urban areas can be higher than that of other development projects.

According to Ruhl and Salzman (2006), the mean distance between the impact and the compensation site in Florida was 26.9 km. In our study, in the 2008–2016 period, we found the distance was 37.3 km for the same area, so it seems that the mitigation banks have become more remote from the impacts in recent years in Florida. BenDor et al. (2007) found a distance of 21.7 km in the Chicago area in the 1993–2004 period, and BenDor and Stewart (2011) found a distance of 50.3 km in North Carolina in the 1996–2007 period. The distance between the place of supply (i.e. the mitigation bank) and the place of demand (i.e. the impact) seems, however, to be low compared to most markets, making a comparison with 'local markets' possible. However, we observed that in southern Florida some compensation sites are quite remote from impacts (the maximum is 221.7 km for the 2008–2016 period); this is probably due to the particularly flat topography of this area or to the fact that even linear impacts are recorded as points. On a local scale, this distance can be considered as unacceptable for social or economic reasons. While from an ecological point of view it seems that the service area allowed the regulator to implement a watershed approach and facilitated environmental planning of wetland compensation, from a well-being point of view it seems impossible to conclude that the mitigation bank led to equivalency for people who lost access to local wetlands and the ecosystem services they supply. This is clearly one of the main shortcomings of MB compared to standard 'on-site' compensation systems and highlights that ecological equivalency cannot be equated with value equivalency (Ives and Bekessy, 2015). However, it should be noted that the assessment of ecosystem service losses and gains is not required by US wetland offset regulations or, more generally, worldwide (Jacob et al., 2016). The primary goal of the current regulation system is ecological equivalency and not welfare equivalency.

3.6. Does Mitigation Banking Risk a Lack of Long-Term Management and Bankruptcy?

3.6.1. Ecological Risk

The primary ecological risk occurs when all the credits of a restoration site have been released and sold and funds have to be secured to continue managing the site. Another possible problem is if the sponsor of the bank has financial difficulties and has to abandon a mitigation bank project (Gardner and Radwan, 2005). There are various potential causes of bankruptcy: a mitigation bank that fails to get its credits, an economic crisis that leads to a lack of demand, or the arrival of another mitigation banker in the same service area, causing the credit price to decrease. The ecological risk depends on the stage of the mitigation plan that has been reached. If no credits have been released or if the released credits have not yet been sold and no other impacts have been authorized, there is no loss. If credits have been released and sold, one can reasonably ask whether the ecological lift 'sold' through the selling of credits will be maintained in the long term.

3.6.2. Regulatory Responses

A conservation easement, if properly enforced, protects a compensation site from any development projects. Even if credits have been sold and the mitigation bank sponsor disappears, the land is very likely not to be directly impacted by development projects. Regulators have also adopted solutions concerning the issue of dependence on long-term management when all the credits have been released. One is that mitigation banks are not approved if their long-term management plan is based on too many cost-intensive engineering measures. It is preferred that the mitigation bank site recovers independent natural functioning that needs only, for instance, the maintenance of a gate surrounding it, or a check for and potential removal of invasive species every 5 or 10 years. The sponsor must also create a long-term stewardship fund that will be transferred to a local organization (NGO) or a public agency to manage the site after the mitigation bank reaches its ecological goals (Final Rule, Section 230.97 (d)) and becomes inactive (i.e. all the credits have been sold).

Regulators also require that the sponsor of the mitigation bank creates, in addition to the long-term management fund, another fund dedicated to the implementation of the management plan during the construction phase (works, plantings, monitoring of success criteria, etc.). This fund may rely on several financial arrangements, of which the performance bond is the most commonly used. A performance bond is a financial guarantee against any failure to observe the terms of the contract. Within the context of mitigation banks, if a mitigation banker goes bankrupt, a third party associated with the performance bond is obliged to release money from the bond to the USACE or any other body responsible for overseeing the mitigation bank project. In this way, regulators are able to carry out the necessary actions to complete the implementation of the mitigation bank, or at least to maintain the ecological lift that has been sold through credits to compensate for impacts.

3.6.3. Efficacy of Regulatory Responses

One key point that is not yet clear is what the level of the long-term stewardship fund must be to ensure real long-term management in the compensatory sites. A recent publication found that in California, these funds are insufficient to manage mitigation bank sites (Thomas, 2016). An evaluation needs to be carried out in other states in the US.

A study by Gardner and Radwan (2005) analyzed the consequences of the bankruptcy of the sponsor in the case of a mitigation bank in New Jersey. A specific problem in this example was that the sponsor did not keep up the monthly payments for the performance bond; therefore, the third party was not obliged to release the performance bond to the administrative body. This type of example has led regulators to be more cautious with financial guarantees. Vaissière and Levrel (2015) analyzed another recent example of bankruptcy. The New Bank (the name has been changed), based in Florida, went bankrupt after selling 17 credits to developers. In order to perpetuate the ecological lift of the 17 credits sold in compensation for several impacts, the USACE recovered the performance bond. With this fund, the USACE financed the continuation of the management plan for the area equivalent to the 17 credits sold. The remainder of the mitigation bank was not considered to be in sufficiently good condition to carry out restoration actions, but it continues to benefit from the conservation easement. This conservation area, which has not been used to compensate for impacts, actually represents an ecological net gain (at least in terms of surface area), since it will now be impossible to develop the site. The fund thus seems to have worked well in this example. However, to our knowledge, there are no guarantees for the financial institution hosting the different types of funds in the event that this institution disappears.

3.7. Does Mitigation Banking Risk Protecting the Market rather than the Environment?

3.7.1. Ecological Risk

BenDor et al. (2011, p.10328) wrote: 'If regulators seek to facilitate markets, they may begin by allowing advance credit sales or larger geographical market areas, thereby absorbing risk from entrepreneurs. The tension currently afflicting these ecosystem market policies lies

between the goals of incentivizing credit supplier market entry versus ensuring that high-quality offsets occur well in advance of impacts and where they are needed most.'

Indeed, a significant risk associated with the development of the compensation market is to consider this new economic sector as an industry to promote and protect, rather than as a tool for implementing public environmental policy. In the US, where the compensation market currently represents a turnover of $2 billion annually, with the number of transactions increasing dramatically over the last 20 years, it is clear that the goals are no longer perceived only as ecological, even by the regulators (Madsen et al., 2011). This explains why compensation is not just an environmental issue, and why a lobby for the MB sector has developed, centered around the NMBA and its local branches in different states.

This lobby tries to drive the system in two directions. The first is to strengthen the requirements for compensation and reject any leeway for developers, because this would create more demand for mitigation banks. In particular, the NMBA acts at the federal level in order to increase the field mitigation banking applies to (to extend it to other habitats not currently eligible) (Hassan et al., 2015). The NMBA can also bring legal actions against regulatory bodies for failure to fulfill compensation obligations (an example is NMBA v. USACE, United States District Court for the Northern District of Illinois, Eastern Division, February 14, 2007; Hassan et al., 2015). The second goal of this lobby is to limit the legal constraints on mitigation banks and to increase those of alternative compensation systems (PRM and ILF), based on the argument that these represent unfair competition for the sector.

In short, it could be tempting for the regulator to relax the rules to facilitate the development of the mitigation bank sector, on the grounds that it generates employment and income (BenDor et al., 2015).

3.7.2. Resilience of the Regulation System: Two Examples

Because it is not easy to identify what solutions a regulator could adopt to limit the influence of MB lobbying, we use two specific case studies that illustrate how this type of situation can cause problems, and how responses to these problems can be adopted at different scales.

The first is the *Solid Waste Agency of Northern Cook County (SWANCC) v. United States Army Corps of Engineers* (2001). In this decision, the US Supreme Court ruled that isolated aquatic ecosystems were not to be taken into account in the Clean Water Act (Christie and Hausmann, 2003). The direct consequence of this decision was that when a development project led to the destruction of these habitats, compensation was no longer required at the federal level. The effect was catastrophic for the MB sector. As described in Robertson (2004, p. 370): 'Suddenly it appears that the USACE no longer had the power to require mitigation for many wetland impacts. The chaos in the banking industry was immediate. (…) Across the country, bankers (…) found that their prospective market had dried up.'

Federal authorities in charge of regulating wetland MB were then in a very uncomfortable situation vis-à-vis operators who had invested in the restoration of this type of habitat and who trusted the ability of the USACE to build the regulatory institutions necessary for the proper functioning of this new market. The regulators could have responded by relaxing the rules following the Supreme Court decision; for example, by accepting that the credits associated with isolated wetlands could be used to offset impacts on other types of habitats, in order to avoid the collapse of an entire economic sector. Another strategy could have been to release the existing credits earlier in order to increase the profitability of the mitigation bank.

However, this is not what happened. States, counties and municipal authorities adopted their own regulatory responses to replace those of the USACE, imposing new compensatory rules that took isolated wetlands into account (Christie and Hausmann, 2003). This was the case in the Jacksonville District, where many counties and municipalities implemented new regulations requiring compensation for these ecosystems, as previously required by the USACE (Christie and Hausmann, 2003). The difference, however, is that the counties and municipalities have required that the compensation remains within their territory. This led to the redefinition of service areas and to a reduction in the distance between compensation sites and impact sites, imposing tighter ecological constraints on mitigation banks (Robertson and Hayden, 2008). Thus, the outcome was that the No Net Loss principle was theoretically respected at a lower level. This example indicates that regulation of the market for wetland mitigation credits seems resilient even in a crisis context, and that, at least in this case, the administrative bodies did not reverse the ends and the means by putting the market before the environment.

The second example is the Highlands Ranch Mitigation Bank in northern Florida (Gardner, 2012). This mitigation bank proposed to restore and preserve 552 acres of wetlands and 1023.5 acres of uplands. Using the UMAM assessment method, the bank requested 688 credits. The Florida Water Management District (FWMD) granted the permit, but for far fewer credits (193.56) than expected by the bank. Of course, this meant a completely different economic return for the investors. To explain this difference in calculating the credits, it is necessary to understand that there are different views in Florida regarding the calculation of the benefits provided by the restoration and preservation of uplands. In this state, two credit markets coexist: federal and Florida state wetland mitigation credits. The USACE does not consider the restoration of uplands as eligible for federal mitigation credits for strict ecological equivalence reasons. But Florida state mitigation credits can apply to uplands in certain circumstances; this depends on the agencies in charge of the assessment, which may judge that uplands surrounding a wetland can be considered as water catchment areas. Two agencies are in charge of delivering mitigation credits: the FDEP and the FWMD. The former allows some credits for uplands (depending on the context), while the latter does not. This point raises a simple fact: although the Final Rule clarified the regulations regarding mitigation credits in the Clean Water Act, the rules adopted by the states to protect their wetlands may not be consistent with this. This was the main source of confusion in this case in Florida and it led to a deep crisis.

The Highlands Ranch Mitigation Bank then asked an administrative law judge to reconsider the assessment carried out by the FWMD; the judge declined to rewrite the state's mitigation banking rules to allow for more credits for upland enhancement and preservation. This left the mitigation bank with one last chance: to appeal to the FDEP. A well-respected FDEP agent reviewed the bank's application and also refused to increase the number of credits for upland compensation projects. But in 2012, this agent's manager made the final decision in favor of the Highlands Ranch Mitigation Bank, which benefited from 425 credits. This episode fueled criticism of MB and received considerable press coverage. Indeed, it can be interpreted as evidence that the system was pressured to support a new economic sector. Yet it should be noted that the final outcome has not gone uncontested: state officials investigated the way top FDEP officials handled this controversial permit. In parallel, in the end the USACE refused to recognize the upland habitat as valid for wetland credits and finally provided only 70.37 credits.

The conclusion regarding the risk of ending up protecting the market rather than the environment is that it depends on the political context and on the checks and balances in the system. The Highland Ranch example seems to illustrate that the mitigation credit system for the Clean Water Act is more resilient than state credit systems.

3.8. Does Mitigation Banking Risk 'Replacing' previously Agreed Conservation Policies?

At a time when public resources devoted to wetland conservation are shrinking, there is a significant risk that mitigation banks may be used as a source of funding for conservation actions that the public sector no longer has the means to conduct. The central issue at stake here is the additionality of measures being used to compensate for impacts. Offsetting standards state that wetland offsets should not be used to replace conservation measures already in place or for which a management plan and funding have previously been identified (BBOP, 2012;

Maron et al., 2015; Walker et al., 2009). Nonetheless, this concern is real and extends to biodiversity offsets in general, as Gordon et al. (2015) raise when they discuss the possible effect of ecological offset policies 'crowding out conservation volunteerism'.

Within the context of MB, certain agreements in the US between the public and private sector can be questioned regarding additionality. In these agreements, the state authorized private stakeholders to carry out restoration actions on land located in areas protected by the state, proposing in return to share the profit from selling the mitigation credits. This could be seen as a way for the state to transfer its environmental commitments to other stakeholders, transforming wetland MB into a financing tool, which is not its intended purpose. Most of the private mitigation bankers we interviewed in Florida were also very critical of these public–private agreements. They view them as a source of unfair competition because the main cost of wetland offsetting, which is usually the cost of the land, does not have to be borne by the private partner in these agreements.

The USACE has attempted to limit these private–public partnerships on public lands which were previously acquired for conservation goals. For instance, in Florida, if a public entity creates a mitigation bank on such a public land, this public entity can only use the offset credits for its own impacts, excepted for a few other cases specified in section 373.4135 (1) (b) Florida Statutes (legislation of the state of Florida). Private mitigation banks are very attentive to this issue and do not hesitate to complain about non-compliance with this rule.

4. Conclusion

This article describes the main ecological risks, as well as certain socio-economic risks, associated with wetland mitigation banking based on its implementation in the US, and particularly in the state of Florida. The regulatory responses and their efficacy have also been analyzed, using empirical evidence to assess whether or not they are able to adapt to the challenges raised by the No Net Loss goal.

We identified eight categories of risk. Of these, the risk of privatization and commodification of wetlands, which would reflect a neoliberal trend and a profound ethical change in conservation practices, seems more a theoretical than a real risk and was not supported by empirical evidence in our analysis. Neither was the risk of facilitating development projects confirmed by the facts; however, this should be qualified by noting that mitigation banks have not resulted in preventing a decrease in the surface area of wetlands in Florida, though it is not possible to definitively determine the respective roles of MB, ILF and PRM methods in this regard. The risk of the homogenization of wetlands is not easy to assess as this would require harmonized national monitoring, allowing a comparison of what has been destroyed by development projects and what has been restored by MB. There is a real risk of temporal loss of wetlands due to the fact that some credits are released before any ecological outputs are gained, but this is compensated by the fact that the credits are sold in stages (the 'temporal gap' is compensated by a 'sale gap'). Another real risk is the disconnection between the impact sites and compensation sites—evidence shows this is a weakness of the mitigation bank system. In Florida, these distances are increasing, leading to a redistribution of ecosystem services for local populations. It is clear that the costs and benefits of this mitigation policy are borne and received by different populations. In terms of the long-term management of a mitigation bank, the risk is not clear: stewardship funds may be insufficient to guarantee long-term management in compensatory sites, but the risk of bankruptcy seems well managed. Finally, in most of wetland MB in Florida, the risk of reversing the ends and means appears to be limited: it does not seem to protect the credit market over the environment, nor does it seem to be used to achieve previously agreed conservation targets.

This leads us to an initial conclusion that the regulatory responses recently adopted to deal with the risks associated with MB seem to be more effective than is often claimed in the literature, although there is still much to be improved. In the US, the USACE and the Environmental Protection Agency (EPA) have created a hybrid system that blends market characteristics and regulatory constraints, which may improve their ability to deal with the challenges of compensating wetland destruction.

However, a second, more worrying, conclusion is that the question is still pending whether or not there is real achievement of No Net Loss of wetlands, including through MB. This leads us to emphasize the need for further research and better national monitoring using adapted, standardized assessment methods regarding the ecological efficacy of MB in the goal of No Net Loss of wetlands. Without these, it will be difficult to draw definitive conclusions about the effectiveness of MB. This is also true for the PRM and ILF methods, if we want to determine the relative effectiveness of each mechanism in the field. At the current time, it is possible to question the capacity of regulators to reach the goal of No Net Loss of wetlands in the US as well as the role of MB in contributing to this goal.

Acknowledgments

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Appendix A. Mitigation Banks of Florida Discussed During the Interviews

Approved (54)	Port Orange
Barberville	Reedy Creek
Bear Point	San Pedro Bay
Big Cypress	Sand Hill Lakes
Big Cypress, Phase VI	Southport Ranch
Blackwater Creek	St. Marks River
Bluefield Ranch	Star 4
Boran Ranch Wetlands	Sundew
Breakfast Point	Sweetwater
Brick Road	Tampa Bay
CGW	Three Lakes Wildlife Mgmt. Area
Colbert/Cameron	TM Econ
Corkscrew Regional	TM Econ Orange County Phase IV
Crosby Island Marsh	Tosohatchee State Reserve
Devil's Swamp	Tupelo
East Central Florida - Eco Bank	Upper Coastal/Citrus Co
Farmton	Wekiva River
Fish Tail Swamp	**Pending (11)**
Florida	Bear Creek
FP&L Everglades Phase I	Easter
FP&L Everglades Phase II	Hatchineha Ranch
Green Swamp	Hillsborough River
Hammock Lake	Horse Creek
Highlands Ranch	IMG (Cherry Lake)
Lake Louisa & Green Swamp Ecobank	Jack's Branch
Lake Monroe	Mill Creek
Lake Swamp	Nochaway
Little Pine Island	Pine Island Estuarine
Loblolly	Withlacoochee Wetland
Loxahatchee	**Withdrawn (2)**
Mary A	Corrigan Ranch
Myakka	Heather Island
Nokuse	**Sold out (2)**
North Florida Saltwater Marsh	Florida Wetlandsbank
North Tampa	Panther Island
Northeast Florida Wetland	**Suspended (2)**
Peace River/Hardee Co	Greens Creek
Pensacola Bay (Westervelt)	Treasure Coast

Appendix B. Interview Outline of the Inquiry on Jacksonville District Mitigation Banks

1 Governance
- 1.1 Governance of the bank
  - History of the bank: Original condition, choices/strategies (why mitigation bank vs. permit, ILF?), what difficulties and uncertainties were faced (what adjustments were made during the work)?

- Who is who? Who does what? Map of the actors of the mitigation banking system on the level of the bank/of your company.
- Major links (alliance, liability, conflicts, support). Formal links: contracts, partnership? Informal links: trust, habit, reputation?
- Your role in the bank: your career (education, previous positions).
- Who fill the RIBITS database? Do you consult the website? Do you like it? Do you use the RIBITS or FL-DEP website more often?
- Number of restored acres for each compensated acre

1.2 Mitigation banking system
- Who is the environmental actor in the mitigation banking system?
- Give your opinion on the environmental aim of mitigation banks. Which position: in favor, against, won over, concession, consensus? Give your opinion on compensatory mitigation in general.
- Ecological efficacy? Which criteria? Three levels for determining equivalence: ecological, spatial, temporal efficacy. What are the main criteria to reach these 3 levels of equivalence?
- What should be the balance between avoid, mitigate and offset (mitigation hierarchy)?
- Do you feel that mitigation banks are more effective than PRM/ILF?
- Does your district apply the preference structure of the rule: 1/Mitigation Banks, 2/ILF and 3/PRM? Another structure? Has the 2008 rule changed anything?
- Influence of the regulators on bank demand: Slow down the bank approval process? Change ecological standards (force mid-way adjustments)? Are you under the impression that the regulators boost or stall mitigation banking in the Jacksonville district? Are regulatory decisions transparent?
- Relations with the regulators: conflicts, trust?
- Obtaining the banking instrument: timeline? Need help to obtain it?
- Administration (institutional dynamics, legal aspects, rules of the game for mitigation banking etc.). Variability of administrative constraints: rules, procedures, bill of specifications, turnover of the people in charge of the cases, etc.
- Is there a lobby for mitigation banking? How could a lobby influence the mitigation banking system: by making the regulatory framework stronger or the guidelines more precise? What influences the success of mitigation banking?

2 Uncertainties

2.1 Environmental
- Uncertainty/risk of environmental success. Restoration failure and degradation: risk of statutory non compliance?
- Conservation easement. How does it work? Does the banker have to maintain the bank? Does he have to allow public access to the bank? On what time scale? Durability of mitigation banks.
- Is environmental variability a constraint? If yes, what are the main constraints? How do you handle them?

2.2 Institutional environment
- 2008 Rule. How? Do you feel it is better, worse? Does it make mitigation approval easier or more difficult? Why?
- Are you confident about its outcome for mitigation banking (role of the 2008 rule)? Anticipated demand?
- Has the Rule reduced the financial risk of establishing mitigation banks in your district? Why? Influence of the Rule on the availability of compensatory mitigation credit from banks? (Increased/decreased/had no effect and why?)
- Do the assessment/control/monitoring/sanction methods play a role in the success of mitigation banking?

2.3 Behaviors
- What are your strategies to get around these uncertainties?
- Does increasing the frequency of interactions decrease uncertainties?
- Do you know bankers who have strategic/opportunistic or disloyal competitive behaviors?
- Adaptation to the 2008 rule. What are your main apprehensions/expectations regarding the evolution of the regulatory framework?
- Crisis situation? Adaptation to this crisis?
- Changes during the last years? What were your strategies of adaptation?

3 Asset specificity

3.1 Credits
- How precise are you about what is behind the name of the credits? Use a label or more/less precise description in RIBITS database?
- How do you determine the credits' value? Assessment methods?
- How important is respecting ecological equivalence (no-net-loss principle)?
- What is the role of the ratios: is it a lever for the authorities?
- How do the USACE/FWS exercise control?
- Who approves the credits and corresponding costs for each step?
- Which actors influence the approval of the credits?
- What is the role of the Interagency Review Team?
- What strategy do you use regarding specificity of assets? Do you try to decrease it or do you benefit from market niche situations in service areas.

3.2 Ecological engineering
- Restoration, preservation, enhancement, restoration/creation actions. Role of the buffer zones?
- Details about ecological engineering actions (methods, who did it, who decides what actions would be taken).
- Relative scarcity of the ecosystem of the bank. Easier if the ecosystem is less specific?
- Do you feel you are transforming/changing the environment? Does it depend on where the restoration actions are done: a different natural area (not a wetland) versus a modified natural area (agriculture, urbanization)? Do you try to choose areas where you can reconnect local hydrological systems?
- How do bankers tradeoff between restoration costs and ecological efficacy of the bank?

4 Credits market and its condition
- Who buys? Why are banks used more than PRM and ILF? How many credits?
- What is the current trend for supply? Is there a risk of flooding the market with credits (too much supply)? Is there regulation of the number of banks based on HUC, district/other factors?
- Condition of the market: oligopolistic, monopolistic or competitive? Is it the same everywhere? What is the current trend?
- Competition regarding the price or the quality: dumping risk with the lowest bidders? Examples? Is mitigation banking competitive?
- Discuss the risk of not having a return on their investments in the short-term but also in the long term. How many years before you

have a return on your investments? Is it slower/quicker since the regulatory framework has been strengthened?
- How does the Rule affect the financial risk experienced by mitigation bankers? (not only supply/demand tension, but also current and future regulator actions)
- Service areas. Very specific market, what is the size of the market? What do you think of this restriction on selling credits? How are these restrictions respected or circumvented? How much leeway is there (for instance, can one pay more to buy more distant credits)? What is the usual scale for the service areas: HUC (8 or 12 digits), geographic regions, hydrologic basin? Is it the same in the different districts? Have the service areas changed in the last few years? How?
- Economic efficacy? How do economic goals affect the ecological management of the site?
- How do you determine your credit price? What are the prices of the credits you sell?
- Is there a risk of financialization of the mitigation banking market: speculation? Can mitigation bankers sell credits to people who do not necessarily do construction on wetlands? For instance, people who wish to invest in credits or people who wish to compensate for other polluting activities (what kinds of equivalences exist for this purchase?)

5 Study on marine environment
- Difference between terrestrial/estuarine banks, which strategy is preferable?
- What other types of ecological compensatory mitigation do you know? Are you familiar with marine environments?
- Suitability of marine environments to carry out ecological compensatory mitigation? Seabed property, regulatory system, which possible conventions (marine law is still incomplete)?
- Opinion on marine mitigation banking? Is ecological engineering less developed and/or more expensive in marine/coastal areas? Are marine/coastal areas more risky (coastal flooding, oil spill, rising water levels due to climate change)?
- Do you think mitigation banks might be located in the open sea? What are the main barriers (seabed property, other). Do you have any ongoing projects in this area?

6 Conclusion
- Is the Florida/Jacksonville case study representative of what is going on in the other states/regions in the United States?
- What other topics have we not discussed? Do you have additional comments?

References

Bayon, R., Jenkins, M., 2010. The business of biodiversity. Nature 466, 184–185.

BBOP (Business and Biodiversity Offsets Programme), 2012. Biodiversity Offset Design, Handbook-Updated. BBOP, Washington (http://bbop.forest-trends.org, consulté le12 novembre 2014).

Bekessy, S.A., Wintle, B.A., Lindenmayer, D.B., Mccarthy, M.A., Colyvan, M., Burgman, M.A., Possingham, H.P., 2010. The biodiversity bank cannot be a lending bank. Conserv. Lett. 3 (3), 151–158.

BenDor, T.K., Riggsbee, J.A., 2011. A survey of entrepreneurial risk in U.S. wetland and stream compensatory mitigation markets. Environ. Sci. Pol. 14, 301–314.

BenDor, T., Stewart, A., 2011. Land use planning and social equity in North Carolina's compensatory wetland and stream mitigation programs. Environ. Manag. 47, 239–253.

BenDor, T., Brozovic, N., Pallathucheril, V.A., 2007. Assessing the socioeconomic impacts of wetland mitigation in the Chicago region. J. Am. Plan. Assoc. 73 (3), 263–282.

BenDor, T.K., Riggsbee, J.A., Doyle, M., 2011. Risk and markets for ecosystem services. Environ. Sci. Technol. 45, 10322–10330.

BenDor, T., Lester, T.W., Livengood, A., Davis, A., Yonavjak, L., 2015. Estimating the size and impact of the ecological restoration economy. PLoS One 10 (6), e0128339. http://dx.doi.org/10.1371/journal.pone.0128339.

Castree, N., 2008. Neoliberalising nature: the logics of deregulation and reregulation. Environ. Plan. A 40, 131–152.

Castree, N., 2010. Neoliberalism and the biophysical environment 1: what 'neoliberalism' is, and what difference nature makes to it. Geogr. Compass 4 (12), 1725–1733.

Christie, J., Hausmann, S., 2003. Various state reactions to the SWANCC decision. Wetlands 23, 653–662.

Dahl, T.E., 2011. Status and Trends of Wetlands in the Conterminous United States 2004 to 2009, Washington.

Dauguet, B., 2015. Biodiversity offsetting as a commodification process: a French case study as a concrete example. Biol. Conserv. 192, 533–540.

Denisoff, C., Urban, D., 2012. Evaluating the success of wetland mitigation Bank. National Wetl. Newsl. 34 (4), 8–11.

Ekins, P., 2003. Identifying critical natural capital: conclusions about critical natural capital. Ecol. Econ. 44 (2–3), 277–292.

FDEP, 2014. Accessed in 2014, but now available on:. http://geodata.dep.state.fl.us/datasets?keyword=biology%20and%20ecology&sort_by=title.

Fressoz, J.-B., 2013. Payer pour polluer. L'industrie chimique et la compensation des dommages environnementaux, 1800–1850. Hist. Mesure XXVIII-I, 145–186.

Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., Wickham, J., 2011. Completion of the 2006 National Land Cover Database for the conterminous United States. PE&RS 77 (9), 858–864.

Gardner, R.C., 2012. Mitigation banking and reputational risk. National Wetl. Newsl. 34 (6), 10–11.

Gardner, R., Radwan, T., 2005. What happens when a wetland mitigation bank goes bankrupt? Environ. Law Report. 35 (9), 10590–10604.

Gordon, A., Bull, J.W., Wilcox, C., Maron, M., 2015. Perverse incentives risk undermining biodiversity offset policies. J. Appl. Ecol. 52 (2), 532–537 (April 1).

Government Accountability Office, 2005. *Wetlands protection*, Corps of engineers does not have an effective oversight approach to ensure that compensatory mitigation is occurring. U.S. Government Accountability Office Report GAO-05-898, Washington, D.C.

Griffin, R.K., Dahl, T.E., 2016. Restoration outcomes and reporting: an assessment of wetland area gains in Wisconsin, USA. Ecol. Restor. 34 (3), 191–199.

Hassan, F., Calvet, C., Vaissière, A.C., 2015. Comparaison des cadres institutionnels américains et français pour la mise en œuvre des banques de compensation. In: Levrel, H., Frascaria-Lacoste, N., Hay, J., Martin, G., Pioch, S. (Eds.), Restaurer la nature pour atténuer les impacts du développement. Analyse des mesures compensatoires pour la biodiversité. Editions QUAE, pp. 157–161.

Hicks, J.R., 1939. The foundations of welfare economics. Econ. J. 49, 696–712.

Hough, P., Robertson, M., 2009. Mitigation under section 404 of the clean water act: where it comes from, what it means. Wetl. Ecol. Manag. 17 (1), 15–33.

Institute for Water Resources, 2015. The Mitigation Rule Retrospective: A Review of the 2008 Regulations Governing Compensatory Mitigation for Losses of Aquatic Resources, October 2015, 2015-R-03.

Ives, C.D., Bekessy, A.A., 2015. The ethics of offsetting nature. Front. Ecol. Environ. 13 (10), 568–573.

Jacob, C., Vaissière, A.C., Bas, A., Calvet, C., 2016. Investigating the inclusion of ecosystem services in biodiversity offsetting. Ecosyst. Serv. 21, 92–102.

Jones, H.P., Schmitz, O.J., 2009. Rapid recovery of damaged ecosystems. PLoS One 4:e5653. http://dx.doi.org/10.1371/journal.pone.0005653 (on line).

Kaldor, N., 1939. Welfare propositions of economics and interpersonal comparisons of utility. Econ. J. 49 (195), 549–552.

Levrel, H., Frascaria, N., Hay, J., Martin, G., Pioch, S. (Eds.), 2015. Restaurer La Nature Pour atténuer Les Impacts Du développement. Analyse Des Mesures Compensatoires Pour La biodiversité, Collection Synthèses, Editions Quae (320 pp.).

Mack, J.J., Micacchion, M., 2006. Ecological Assessment of Ohio Mitigation Banks: Vegetation, Amphibians, Hydrology, Soils. Ohio EPA Technical Report WET/2006–1. Ohio Environmental Protection Agency, Division of Surface Water, Wetland Ecology Group, Colombus, Ohio.

Madsen, B., Carrol, N., Moore Brands, K., 2010. State of biodiversity markets report: offset and compensation programs worldwide. Ecosystem Marketplace, Washington, p. 73.

Madsen, B., Carrol, N., Kandy, D., Bennett, G., 2011. *Update*. State of biodiversity markets report: offset and compensation programs worldwide. Ecosystem Marketplace, Washington, p. 73.

Maron, M., Gordon, A., Mackey, B.G., Possingham, H.P., Watson, J., 2015. Stop misuse of biodiversity offsets. Nature 523, 401–403.

Mauss, M., 1924. The Gift: Forms and Functions of Exchange in Archaic Societies. Cohen & West, London.

Moreno-Mateos, D., Power, M.E., Comin, F.A., Yockteng, R., 2012. Structural and functional loss in restored wetland ecosystems. PLoS Biol. 10 (1), e1001247.

Murphy, J., Goldman-Carter, J., Sibbing, J., 2009. New mitigation rule promises more of the same: why the new corps and EPA mitigation rule will fail to protect our aquatic resources adequately. Stetson Law Rev. 38 (2), 311–336.

National Research Council, 2001. Compensating for wetland losses under the Clean Water Act. National Academy Press, Washington DC.

NLCD, 2011. National land cover database, United States. http://www.mrlc.gov/nlcd2006.php (accessed in 2016).

Pearce, D.W., Atkinson, G.D., 1993. Capital theory and the measurement of sustainable development: an indicator of "weak" sustainability. Ecol. Econ. 8, 103–108.

Quétier, F., Regnery, B., Levrel, H., 2014. No net loss of biodiversity or paper offsets? A critical review of the French no net loss policy. Environ. Sci. Pol. 38, 120–131.

RIBITS, 2015. Regulatory in-lieu fee and bank information tracking system. https://ribits.usace.army.mil/ribits_apex/f?p=107:2 (accessed 11/25/2015).

RIBITS, 2016. Regulatory in-lieu fee and bank information tracking system. https://ribits.usace.army.mil/ribits_apex/f?p=107:2 (accessed 07/20/2016).

Robertson, M.M., 2004. The neoliberalization of ecosystem services: wetland mitigation banking and problems in environmental governance. Geoforum 35 (3), 361–373.

Robertson, M., 2008. The entrepreneurial wetland banking experience in Chicago and Minnesota. National Wetlands Newsletter 30 (4), 14–17.

Robertson, M., Hayden, N., 2008. Evaluation of a market in wetland credits: entrepreneurial wetland banking in Chicago. Conserv. Biol. 22, 636–646.

Ruhl, J.B., Salzman, J., 2006. The effects of wetland mitigation banking on people. National Wetl. Newsl. 28 (2), 8–13.
Scemama, P., Levrel, H., 2014. L'émergence du marché de la compensation des zones humides aux États-Unis: impacts sur les modes d'organisation et les caractéristiques des transaction. Rev. Econ. Polit. 123 (6), 893–924.
Spash, C., 2015. Bulldozing biodiversity: the economics of offsets and trading-in nature. Biol. Conserv. 192, 541–551.
Spieles, D.J., Coneybeer, M., Horn, J., 2006. Community structure and quality after 10 years in two Central Ohio mitigation bank wetlands. Environ. Manag. 38, 837–852.
Teresa, S., 2008. Perpetual stewardship considerations for compensatory mitigation and mitigation banks. Stetson Law Rev. 38, 337–356.
Thomas, J., 2016. Evaluating long-term stewardship of compensatory mitigation sites: preliminary findings from California. National Wetl. Newsl. 38, 2.
USACE, 2016. ORM jurisdictional determinations and permit decisions. http://corpsmapu.usace.army.mil/cm_apex/f?p=340:2:0::NO.
USACE, EPA, 2008. Compensatory Mitigation for Losses of Aquatic Resources; Final Rule. Federal Register, 73 Fed. Reg. 70, 19593–19705 (242 pp.).
Vaissière, A.C., Levrel, H., 2015. Biodiversity offset markets: what are they really? An empirical approach to wetlands mitigation banking. Ecol. Econ. 110, 81–88.
Vaissière, A.-C., Levrel, H., Scemama, P., 2016. Biodiversity offsetting: clearing up misunderstandings between conservation and economics to take further action. Biol. Conserv. (in press).
Walker, S., Brower, A.L., Stephens, R.T.T., Lee, W.G., 2009. Why bartering biodiversity fails. Conserv. Lett. 2, 149–157.
Wende, W., Herberg, A., Herzberg, A., 2005. Mitigation banking and compensation pools: improving the effectiveness of impact mitigation regulation in project planning procedures. Impact Assess. Proj. Apprais. 23 (2), 101–111.
Wilkinson, J., Thompson, J., 2006. 2005 Status Report on Compensatory Mitigation in the United States.