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Managing Risk in Environmental Markets

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SUMMARY

Environmental markets use voluntary approaches to meet regulatory requirements and to target cost-effective, flexible, and efficient means to achieve environmental results. Although these markets create opportunities, they also involve some risk for regulated buyers, project developers (sellers), landowners, and the public. This paper reviews technical risk, extreme events, behavioral uncertainty, regulatory uncertainty, and market uncertainty in four markets that engage agricultural and forest landowners in the United States: wetland and stream mitigation banking, conservation banking, greenhouse gas offsets, and water quality trading. Because these markets involve transactions that range from annual to permanent transfers of environmental benefits, they entail different risks and liabilities.

Given robust risk management strategies and significant similarity across programs, only a few risk management mechanisms have yet to be tried in all markets. One such mechanism is clarifying rules about how water quality and carbon offsets projects can sell into multiple markets, thereby enhancing flexibility and reducing risk for buyers and sellers. None of the markets currently use but all could consider purchase guarantees to encourage supply generation. Another risk management opportunity may be presented by vertical integration of regulatory programs, in which buyers become project developers to control risk. Finally, water quality trading markets could use credit banks to connect buyers and sellers. These banks might work best if they serve a clearinghouse function, providing market coordination and information.

Executive Summary

Environmental markets use voluntary approaches to meet regulatory requirements and to target cost-effective, flexible, and efficient means to achieve environmental results. Although these markets create opportunities, they also involve some risk for all those engaged—the regulated buyers, project developers (sellers), landowners, and the public. This paper reviews five types of risk these actors face—technical risk, extreme events, behavioral uncertainty, regulatory uncertainty, and market uncertainty—in four markets that commonly engage agricultural and forest landowners in the United States—wetland and stream mitigation banking, conservation banking, greenhouse gas offsets, and water quality trading. These markets involve transactions that range from annual to permanent transfers of environmental benefits and thus entail different risks and liabilities.

Across the four markets, risk management approaches appear relatively similar. Most dissimilar are permanent offsets and term or annual offsets. These two types of offsets use different risk management mechanisms due to differences in the nature of their risks. These differences do not appear to be due to more or less regulatory investment in risk management.

Risk management mechanisms in some markets might be transferable to other markets. First, wetland stream and species mitigation banking hedge risk by having clear rules about how banks can sell into multiple markets, those driven by both the Clean Water Act and the Endangered Species Act. The rules for how carbon and water quality sellers can access other markets are less clear. Second, carbon credit banking allows greater flexibility for buyers and sellers who can reduce risk in the carbon market—an approach that might be transferable to other annual or term credits. Third, purchase guarantees to encourage supply generation not yet seen in any of these markets could be considered for all of them. Fourth, vertical integration of programs—in which buyers become project developers to control risk—might be useful across markets. And finally, a credit bank approach in which a centralized intermediary connects buyers and sellers has been proposed for water quality trading. Although a credit bank could operate like in-lieu fee programs (institutional buyers), which have run into difficulties in wetland and stream mitigation applications, it could instead function like a clearinghouse, providing only market coordination and information. A number of these options seem worthy of further exploration.

Overview

Introduction

Environmental markets use economic incentives to drive the most cost-effective, flexible, and efficient means to achieve environmental results. These markets may increase engagement of the private sector through delivery and investment. They continue to grow as tools to meet regulatory and mitigation needs.

In environmental markets, a unit of environmental benefit—for example, a ton of greenhouse gas equivalence, pound of nitrogen, or acre of wetland habitat—is exchanged by entities. The standard and details of transactions are usually designed to meet federal or local regulatory requirements. These transactions require the involvement or approval of a regulatory body.

Many environmental markets focus on agricultural, range, and forest lands as opportunities to protect or enhance environmental services and thereby offset or mitigate environmental impacts. Those who engage in these markets face a variety of risks and thus liabilities that must be managed. This paper

- Provides an overview of the risks to buyers, sellers, and landowners across different types of environmental markets;
- Discusses programmatic risks—that is, risks fully attributed to neither buyer nor seller and that therefore are the responsibility of the regulatory authority or accumulate as losses of environmental benefits;
- Reviews approaches in program designs (regulatory structure and guidelines) for managing these risks;
- Traces liabilities for remaining risks and how they are held by buyers or sellers;
- Compares and contrasts how risks and liabilities are shared across these markets; and
- Broadly describes some external mechanisms (outside program design) such as private or publicly backed insurance for managing risks and uncertainty.

Advancement of environmental markets could be hindered by real or perceived risks. In 2006, for example, John Powers of the U.S. Environmental Protection Agency (EPA) expressed concerned about the effect of risk on water quality trading, noting that "Real progress is possible with improved understanding of actual and perceived risks and improved risk management" (Powers 2006).

This paper covers four environmental markets: (1) wetland and stream banking driven by the Clean Water Act no-net-loss objective, (2) conservation banking for threatened and endangered species, (3) greenhouse gas offsets driven by California's greenhouse gas policy, and (4) water quality trading developed to respond to Clean Water Act and state regulations. These markets involve transactions that range from annual to permanent transfers of environmental benefits and that therefore entail different risks and liabilities.

The markets address two types of impacts: permanent impacts and ongoing pollutant releases. Permanent impacts, like the development of a new area, usually require permanent offsets to replace losses. These permanent offsets are needed in wetland, stream, species, stormwater, and water quality programs. Ongoing pollutant releases, like greenhouse gas emissions, wastewater releases from treatment facilities, or heated water from energy facilities, are often addressed through annual reductions in pollutant loads with multiyear contracts. These reductions (annual or term offsets) are most often part of water quality trading and greenhouse gas offset programs, but longer-term (say, 20-year), non-permanent contracts for offsets are being tried for species habitat protection (Doherty et al. 2010; U.S. FWS 2007; U.S. FWS 2014; Wolfe et al. 2012) and in the past were used to address forest carbon (Box 1).

Box 1. Characteristics of Permanent and Annual Offsets

*Permanent Offset**

A project will have a **permanent impact** on the environment (e.g., filling or dredging a wetland, destroying species habitat and harming species, or adding impervious surface, which also removes nutrient retention) thus will require a permit. The **permittee is typically required to avoid, minimize, and then compensate (mitigate) for the impact**. The permittee can achieve needed mitigation through onsite or offsite offsets (compensatory activity) without a market mechanism (e.g., through permittee-responsible mitigation, habitat conservation plans, or onsite stormwater reductions). Alternatively, the permittee can use credits developed by third parties that will replace or protect lost environmental benefits at other sites. **Market mechanisms often involve pre-impact compensatory projects developed by third parties (e.g., banks)**—projects that produce benefits that can be sold to multiple buyers. These third-party market-based projects almost always require **regulator-verified activities, monitoring, and maintenance plans as well as permanent easements and financial assurance mechanisms**. In addition, they typically require completion of some if not all project activities (e.g., restoration, management, construction) before sale of environmental benefits. These **benefits are typically sold—once only**—in the form of credits, and the product is most often **delineated in measures such as acres or habitat acres**.

Annual (or Term) Offset

An entity conducts an activity that has an **annual, permitted, allowable release of a pollutant** (e.g., greenhouse gas, nutrients, heat). The permittee can either **comply with its pollution limit by reducing emissions from its facility or by creating or purchasing a verified offset**. Annual or term offset projects will sometimes involve short-term management activities (like changing fertilizer application on a farm) but more often will involve projects that can, over the long term, **provide annual increments of reduction** like a shaded stream buffer to reduce temperature, a fence to keep cattle out of a stream, or a digester to capture and use/burn methane from livestock manure. These projects typically **require no permanent easements, monitoring plans, or financial assurance mechanisms; instead, they usually require frequent verification** to ensure that they are properly operating. These projects can **sell credits every year** on the basis of the level of pollutant reduction they achieve; the product is most often delineated in measures such as **pounds of nitrogen, tons of carbon dioxide equivalents**.

*Water quality trading and mitigation mechanisms for species are developing approaches for using a series of annual or term offsets/credits to address a permanent impact (replacing a permanent offset).

Who Is at Risk and What Risks Do They Face?

Multiple parties are potentially at risk in environmental markets.

Buyers are the regulated or permitted entities that may want to purchase environmental benefits/credits to cost-effectively meet regulatory requirements. They face the risk that credits/benefits are not available when they are needed. They also face the risk that purchased benefits for some reason fail to meet a program's regulatory requirements. In that case, civil suits and penalties (legal fines), other expenses, and reputational risks might result.

Sellers are the landowners, land managers, or brokers (e.g., aggregators, bank sponsors) who develop and manage environmental projects to produce a supply of environmental benefits/credits that can be sold. Brokers can be private companies (mitigation bankers, engineering firms), non-governmental organizations, or local or state governments. Non-governmental organizations and state and local governments are usually involved through what are called in-lieu fee programs in wetland and stream markets.[1] Historically, these in-lieu fee programs held less risk than other mechanisms due to relatively less restrictive standards, but with the 2009 rule that requires equivalent standards for all forms of offsets/credits, this has changed. Sellers face the risk of regulatory uncertainty, which may mean that demand is not forthcoming or requirements for crediting do not meet expectations, undercutting potential profits and encumbering developers with costs or restricted land holdings. They also face risks associated with natural systems, variability, and extreme events that can undermine projects and increase project costs. In addition to increased costs or decreased profits, sellers can face reputational risk and liability for failure to meet contract terms. If sellers take on full responsibility and liability for projects as they do in some markets, they can face the same risks as buyers with regard to civil suits and penalties.

Landowners who have projects on their lands, even if they are not the direct sellers (i.e., they are working with a broker), may also face risks. They face the risk that their property is encumbered temporarily or permanently by contractual restrictions. And if a program fails to develop as expected and the value of credits is low or if demand for land shifts and the development value of the property increases, the landowners bear these opportunity costs.

Regulatory programs that use offsets are often developed to promote a public good, like no net loss of healthy wetland systems and the services they provide. Often these programs do not pass on all risks to buyers and sellers but instead leave some risks to be held by the public. These risks can be substantial and can result in loss of the ecosystem functions that the programs are designed to sustain.

Types of Risk

Risks associated with the development and creation of environmental mitigation and offset projects are held by sellers or brokers. Once purchased, risks and liabilities often shift from the buyer to the seller. Even when regulations place liability on the buyers, contracts are usually used to shift financial liability to

[1] "In-lieu fee program means a program involving the restoration, establishment, enhancement, and/or preservation of aquatic resources through funds paid to a governmental or non-profit natural resources management entity to satisfy compensatory mitigation requirements for DA (Department of the Army) permits. Similar to a mitigation bank, an in-lieu fee program sells compensatory mitigation credits to permittees whose obligation to provide compensatory mitigation is then transferred to the in-lieu program sponsor" (40CFR Subpart J 230.92).

the seller. When placing the risk with the seller, contracts build that risk into the overall cost of the offset/mitigation. Conversely, when risk stays with the buyer, contracts do not include the price of risk in the cost of the offset/mitigation.

The following framework covers five types of performance risk and the mechanisms embedded in program designs to reduce each risk across environmental markets. This framework is adapted from Walker and Selman (2014).

- **Technical Risk**

  Natural lag time—Natural time lags affect most environmental markets. It takes time for pollutant reductions to reach target water bodies, for trees to establish and store carbon, and for wetlands to provide habitat, nutrient, and hydrological benefits.

  Natural variability—Natural variability—the day-to-day and year-to-year changes in pollutant and emissions reductions, carbon storage, and habitat establishment—affects how environmental performance is quantified and credited.

  Scientific uncertainty—Scientific uncertainty in quantification of environmental credits is greater in some programs (e.g., species recovery) than others (e.g., carbon sequestered in trees). There is also scientific uncertainty about the overall environmental benefits produced by environmental market programs.

- **Extreme Events**
  Extreme events such as droughts, flood, earthquakes, and hurricanes can completely destroy the functionality of multiple or most environmental benefits in a region or watershed and therefore create risks that are difficult to manage.

- **Behavioral uncertainty (e.g., failed projects)—**Every market has mechanisms to ascertain whether sellers, project developers, or brokers intentionally or unintentionally failed to create or maintain the promised environmental benefits that were sold as environmental credits to others. This uncertainty is sometimes called *buyer risk* (Willamette Partnership, Pinchot Institute for Conservation, and World Resources Institute 2015).

- **Regulatory uncertainty**—In developing or contentious regulatory environments, there may be questions about whether regulations will be implemented or held up by lawsuits, whether performance standards will changed, and whether rules will be weakened or delayed. These questions create uncertainty and risk for both buyers and sellers. Uncertainty or lack of transparency about rules, requirements, and priorities can also create risk for buyers and sellers of environmental credits.

- **Market Uncertainty**
  For buyers, uncertainty about credit availability and price can create risk. For sellers, uncertainty about demand for developed environmental benefits and credits can create risk. Uncertainty about

market demand brings with it uncertainty about the value of the credits that sellers are developing. In regulatory-driven markets, uncertainties about supply, demand, and the value of credits are shaped by the way regulatory programs are designed.

No matter what programmatic mechanisms are used to minimize risk, some risk remains. To manage this remaining risk, buyers and sellers can use external (non-programmatic) mechanisms such as transferring risk to other parties (brokers use contracts; third parties use insurance), holding diversified portfolios, or vertically integrating programs (whereby buyers step in to create credits, eliminating the need for external sellers).

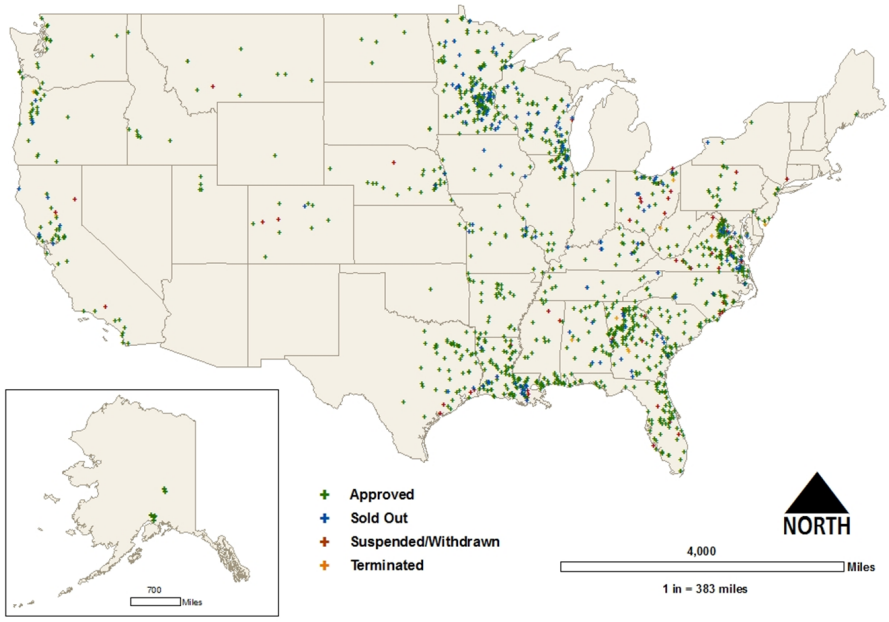
Wetland and Stream Mitigation Banking

The federal government has an overarching goal for "no overall net loss" of wetlands (U.S. EPA 1990). Mitigation policy through the Clean Water Act's 404 permit program contributes to this national goal and also integrates impacts to streams. The guidance requires avoiding and minimizing impacts and compensating for remaining impacts to the extent practicable and appropriate. Compensatory mitigation is required to offset significant losses of aquatic resources or functions: "*Compensatory mitigation* involves actions taken to offset unavoidable adverse impacts to wetlands, streams and other aquatic resources authorized by Clean Water Act section 404 permits…" (33CFR332).

Compensatory mitigation can be implemented in three ways: permittee-responsible mitigation, in-lieu fee (ILF) programs, and mitigation banks (33CFR332). In-lieu fees and mitigation banks are referred to as third-party mitigation because the liability is shifted to the in-lieu fee provider or the bank sponsor to achieve performance success. In permittee-responsible mitigation, the permittee retains legal responsibility, and the risk is not shifted by law (but could be shifted through contract to a third party provider). In 2008 the government released a revised compensatory mitigation rule with significantly updated implementation guidance. The 2008 rule creates a preference for the use of bank credits—the focus of this discussion of environmental market mechanisms and liability.

Compensatory mitigation banks are found across the country (Figure 1). These banks allow off-site compensatory mitigation activities to be conducted by a third party—a mitigation banker—that assumes responsibility for ensuring that compensation is complete and successful. Banks are commonly operated as for-profit entities. According to U.S. Army Corps of Engineers' (USACE) Regulatory In lieu fee and Bank Information Tracking System (RIBITS), 77% of banks were commercial enterprises—most sponsored by the private sector—as of 2015 (USACE 2015).

Figure 1. Location of 404 stream and wetland mitigation banks in RIBITS database as of August 2015



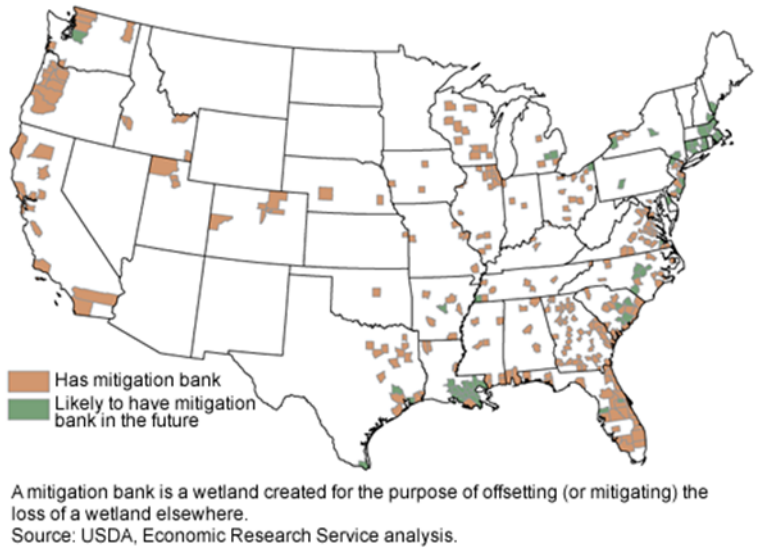
Source: USACE.

Four types of mitigation practices generate credits: restoration of a previously existing wetland or other aquatic site, enhancement of an existing aquatic site's functions, establishment (i.e., creation) of a new aquatic site, and preservation of an existing aquatic site.[2] Which of these practices is allowed and what activities count for mitigation vary, given Corps district priorities and state laws. For example, in North Carolina, preservation of existing aquatic sites is not a preferred activity, although this practice may be used in conjunction with restoration. But in New England, restoration of fish passage through removal of small dams and weirs and replacement of undersized or perched culverts is an increasingly important mechanism of compensatory mitigation.[3]

Agricultural lands are commonly used for the creation of mitigation banks. A recent assessment by the U.S. Department of Agriculture (USDA) Economic Research Service found that 60% of counties with mitigation banks have agricultural lands that were once wetlands. Thus it is no surprise that these former wetlands make good sites for mitigation banks (Figure 2).

[2] The 2008 rule uses the terms *reestablishment, rehabilitation, enhancement,* and *preservation*.
[3] Steve Martin (U.S. Army Corps of Engineers Institute for Water Resources), to the author, August 14, 2015.

Figure 2. Counties with or likely to have agricultural lands serving as mitigation banks for wetland losses



A mitigation bank is a wetland created for the purpose of offsetting (or mitigating) the loss of a wetland elsewhere.
Source: USDA, Economic Research Service analysis.

Source: USDA Economic Research Service.

Who Is at Risk and What Risks Do They Face?

USACE administers the CWA 404 program with oversight by the EPA. The program requires that impacts to jurisdictional waters and wetlands be avoided and minimized to the maximum extent practicable. If losses of aquatic resources are unavoidable, onsite or offsite mitigation will likely be required for a permit to be issued and for projects with these impacts to move forward. Developers, builders, or departments of transportation that are faced with mitigation requirements (the buyers) can purchase mitigation credits from approved mitigation banks (the sellers) where available. Mitigation banks take the responsibility and risks inherent in maintaining wetland and stream compensatory mitigation sites from the regulated permittee. All compensatory mitigation liability is transferred from permittees to banks with the sale of credits.

The banks also hold the risks inherent in developing and creating the wetland and stream sites so that they will meet regulatory standards. These standards and their implementation vary across the ACE districts that manage the permit system and crediting. State and local laws can also affect siting, construction permitting, and other requirements for mitigation banks. The permittee retains liability for maintaining the authorized fill in accordance with the permit as well as for complying with other federal and state requirements associated with the permitted activity (e.g., erosion and sediment controls) and the Endangered Species Act (ESA).

Conservation banks transfer liability from the permittees to bank sponsors, which are most commonly for-profit enterprises but which can also be non-profit or government organizations. In lieu fee (ILF) programs, like banks, transfer liability from permittees to the sponsors of ILF programs, which are often non-profit or government programs. Permittee-responsible mitigation (PRM) leaves all the liability and risk with the permittees. This paper focuses on managing the risks of mitigation banks and does not further discuss these other mechanisms.

The role of landowners in wetland and stream mitigation varies. They may be able to sell lands to mitigation banks and thus be removed from any risks of the program. However, they may also, particularly in the context of stream mitigation, be paid to provide easements on their lands that will be managed by mitigation banks. Although the banks will assume program risks, the landowners can bear the risk of opportunity costs if alternative values for their lands increase above the level of compensation received for the easements.

If mitigation does not fully replace losses in wetlands and streams, these losses fall to the public with the only recourse being civil suits against regulators to compel stricter enforcement and public pressure for revision of and improvement in federal-, district-, and state-level rules.

Five Types of Uncertainty and How They Can Be Managed

Numerous mechanisms in compensatory mitigation policy help mitigation banks manage the five types of uncertainty that lead to risk.

Technical Risk

Natural Lag Time

The time lag between an impact and a functioning replacement ecosystem (wetland, stream, or coastal area) is a concern if on balance net total ecosystem functions are lost for a period (BenDor, Holtes, and Doyle 2009). A significant lag time is more likely for establishment of systems like bottomland hardwoods than for recovery of stream function after removal of a small dam (Stanley, Luebke, Doyle, and Marshall 2002; Allen et al. 2001).

Management Strategies:

- **Project in advance of impact:** So-called advanced mitigation is increasing in popularity. One of the reasons that the 2008 rule stated a preference for mitigation banks over other mechanisms for compensatory mitigation is that banks cannot release credits until a bank instrument, a mitigation plan, and real estate and financial assurances are in place, thereby creating some certainty that an appropriate mitigation activity will proceed (33CFR332(b)(2)). And in many cases a mitigation bank will be established and producing environmental benefits before credits are sold. However, advance mitigation does not remove the risk of temporal loss. An initial 15–30% of anticipated credits can be released and sold to finance construction before completion of a fully ecologically functioning mitigation bank. In some cases, this percentage can make up a significant proportion of eventually sold credits (Robertson 2006; Gardner 2011). The district engineer is tasked with eliminating or reducing lag times or for compensating for them with crediting.[4] Other types of programs, like ILF programs, could also establish advance mitigation and require that projects be completed before they can accept payments, but this is not always the case.

[4] "Implementation of the compensatory mitigation project shall be, to the maximum extent practicable, in advance of or concurrent with the activity causing the authorized impacts. The district engineer shall require, to the extent appropriate and practicable, additional compensatory mitigation to offset temporal losses of aquatic functions that will result from the permitted activity" (33CFR332_(m)).

- **Credit release schedules:** Banks are required to have clear, enforceable performance standards and credit release schedules tied to these standards, which can control how credits are released prior to habitat maturity.

- **Additional credits required to cover lag**: Regulators can require additional compensatory mitigation to address temporal loss or a lag in replacement of function (332.3(f)(2)). This can help reduce the impact of lag times on project development and on the environment.

Natural Variability

There is significant natural variability in the ecosystem functions and services provided by aquatic ecosystems given their form (size, shape, type) and locations (Cole, Brooks, and Wardrop 1997). In some places these ecosystems can provide good habitat for species; in others they may regulate flow rates and reduce nutrient loadings. In theory for compensatory mitigation programs, the functions created (gained) by the new or restored system should be in the same geographic location and of the same types and magnitude as those lost. Therefore, variability in form, location, and function must be considered in quantification of the credits needed for impacts and the credits created by mitigation projects. Because natural variability can result in bad timing or locations (e.g., drought, invasive species) for restoration and creation of aquatic systems, it may generate significant uncertainties for banks.

Management Strategies:

Variability resulting from the type and location of impacts relative to mitigation is taken into account through the use of watershed-scale planning, requirements for same-watershed mitigation (mitigation in the same watershed as the impact), and a preference for same-kind mitigation. The selection of mitigation site is critical. And credit release schedules can be used to help address variability in ecological recovery once a project is under way.

- **Watershed planning:** To the extent appropriate and practicable, mitigation requirements must be established with a watershed-scale approach.[5] The district engineer is required to use a watershed plan where such a plan is appropriate and available, and when there is no such plan, the bank sponsor is required to assess watershed information about its site. In addition to matching the compensatory action to the impact, this requirement is intended to result in a "strategic selection" of mitigation sites to maintain and improve aquatic resources.

  Existing statewide or watershed plans for use by district engineers are rare. The Wisconsin program requires a watershed geographical information system (GIS) analysis (Wisconsin DNR 2014), and North Carolina has a statewide prioritization process for its ILF program at the scale

[5] "A watershed approach to compensatory mitigation considers the importance of landscape position and resource type of compensatory mitigation projects for the sustainability of aquatic resource functions within the watershed. Such an approach considers how the types and locations of compensatory mitigation projects will provide the desired aquatic resource functions, and will continue to function over time in a changing landscape. It also considers the habitat requirements of important species, habitat loss or conversion trends, sources of watershed impairment, and current development trends, as well as the requirements of other regulatory and non-regulatory programs that affect the watershed, such as stormwater management or habitat conservation programs. It includes the protection and maintenance of terrestrial resources, such as non-wetland riparian areas and uplands, when those resources contribute to or improve the overall ecological functioning of aquatic resources in the watershed" (33CFR332. 3(c)).

of the service area (NC DEQ). Although not as comprehensive, many programs do require that some landscape- or watershed-scale indicators be included in wetland and stream assessments done for impact and mitigation sites.[6] The absence of a more formal watershed-scale strategic selection and targeting of sites for mitigation banks may increase uncertainty about the aquatic functions gained by those banks.

- **Same watershed/service area**: The 2008 rule states that in general, "the required compensatory mitigation should be located within the same watershed as the impact site, and should be located where it is most likely to successfully replace lost functions and services, taking into account such watershed scale features as aquatic habitat diversity, habitat connectivity, relationships to hydrologic sources (including the availability of water rights), trends in land use, ecological benefits, and compatibility with adjacent land uses" (33CFR332). The rule also states that the size of the watershed should not be "larger than is appropriate to ensure that the aquatic resources provided through compensation activities will effectively compensate for adverse environmental impacts …." As a result, many USACE districts use an eight-digit hydrological unit code (HUC8) (average 700 square miles) to establish the watershed scale within which they require both impacts and compensatory actions to occur. This scale is often called the service area.

- **Same kind of mitigation**: Overwhelmingly, permits favor in-kind mitigation over out-of-kind mitigation in hopes of better compensating for the functions and services lost at the impact site. However, out-of-kind mitigation may be preferable in some circumstances—for example, to restore a large aquatic resource or complex of habitats or a particularly vulnerable or valuable wetland habitat type. In general, out-of-kind mitigation is appropriate when it is practicable and provides more environmental or watershed benefits than in-kind compensation (USACE 2002).

- **Credit release schedules:** Banks are required to have clear enforceable performance standards and credit release schedules tied to these standards, thereby reducing risk and uncertainty in habitat restoration and environmental outcomes (replaced functions) caused by natural variability. Although this requirement reduces the risk that public benefits will be lost, it creates a risk for the bank sponsor, increasing uncertainty about when USACE and its interagency review team (IRT) will determine that the bank has met performance standards sufficient for credit release.

- **Variable crediting:** Variability can be considered in the setting of ratios or accounting rules. In practice, most USACE districts set requirements for function or condition assessments of mitigation sites to determine how much mitigation is required and how much is created at a bank site. The district engineer is required to set a "mitigation ratio greater than one-to-one where necessary to account for" anything that would suggest the compensatory mitigation functions were less than the affected functions (e.g., lag times, type of mitigation, location) (33CFR332). Often these ratios and accounting rules are specified in district assessment methods, but they are subject to USACE discretion.

[6] See, for example, the North Carolina Department for Environmental Quality Division of Water Resources' North Carolina Wetland Assessment Method (NCWAM) at http://portal.ncdenr.org/web/wq/swp/ws/pdu/ncwam-manual and the Ohio Environmental Protection Agency's Ohio Rapid Assessment Method for Wetlands v. 5.0 User's Manual and Scoring Forms at http://www.epa.state.oh.us/portals/35/401/oram50um_s.pdf.

Scientific Uncertainty

Scientific uncertainty around how to measure and account for the functions and services that are provided by restored and created aquatic systems is significant (Palmer, Hondula, and Koch 2014; Moreno-Mateos, Power, Comin, and Yockteng 2012). Scientific uncertainty about whether creation and restoration of aquatic systems will replace lost functions at impact sites is also significant. A recent study of mitigation wetlands completed by the Ohio EPA showed that well over half of the sampled sites were considered failures and even more were far from meeting ecological performance standards (Micacchion, Gara, and Mack 2010). A study in Texas found that current methods of reestablishing vegetation were not sufficient for establishing compensatory wetlands that are similar to neighboring reference wetlands (Wall and Stevens 2014).

Management Strategies:

Scientific uncertainty in the measurement of ecological function and services for aquatic systems are considered in the use of simple measures, like acres, but there is also a move toward more functional measures as a way to potentially improve measurement and accounting of aquatic benefits. Scientific uncertainty is also addressed by handling special, difficult-to-replace wetland systems differently than other wetland systems. However, science suggests that our knowledge of how to create and restore these systems is insufficient.

- **Review of ecological suitability of mitigation site:** The district engineer can assess the ecological suitability of the mitigation site by considering a wide range of hydrological and biological features.[7]

- **Special provisions for difficult-to-replace resources:** Many districts have special provisions for avoiding damage to and replacement of difficult-to-replace resources like streams, bogs, and fens.

- **Accounting methodologies:** Most districts have assessment methods to account for the type of aquatic system and some of its key features (e.g., type of wetland, stream characteristics, endangered species) for affected and compensatory mitigation sites.

- **Accounting for function:** Some mitigation programs still use simple measures of extent, like acres of wetland or linear feet of stream, but many now use some measures of type and resource

[7] "The compensatory mitigation project site must be ecologically suitable for providing the desired aquatic resource functions. In determining the ecological suitability of the compensatory mitigation project site, the district engineer must consider, to the extent practicable, the following factors: (i) Hydrological conditions, soil characteristics, and other physical and chemical characteristics; (ii) Watershed-scale features, such as aquatic habitat diversity, habitat connectivity, and other landscape scale functions; (iii) The size and location of the compensatory mitigation site relative to hydrologic sources (including the availability of water rights) and other ecological features; (iv) Compatibility with adjacent land uses and watershed management plans; (v) Reasonably foreseeable effects the compensatory mitigation project will have on ecologically important aquatic or terrestrial resources (e.g., shallow sub-tidal habitat, mature forests), cultural sites, or habitat for federally- or state-listed threatened and endangered species; and (vi) Other relevant factors including, but not limited to, development trends, anticipated land use changes, habitat status and trends, the relative locations of the impact and mitigation sites in the stream network, local or regional goals for the restoration or protection of particular habitat types or functions (e.g., re-establishment of habitat corridors or habitat for species of concern), water quality goals, floodplain management goals, and the relative potential for chemical contamination of the aquatic resources" (33CFR332. 3(d)).

condition, focusing on compatible types of wetland or riparian systems to assess credits for impacts and compensatory activities (U.S. EPA 2002; Ohio EPA 2001). Some mitigation programs are moving toward functional assessments that account for the range of functions being lost, like water quality benefits in Wisconsin. Others are moving toward a crediting system tied to either mitigation practices or functions gained, as seen in West Virginia and Virginia. These variations in methods are an exercise in balancing reduced certainty with costs and ease of use. One of the issues raised about functional approaches is that the science cannot yet consistently provide credible quantification of functions.

Effect of Management Mechanisms on Risks and Liability:
Where required, constraints on credit releases to address time lags can be a burden on bank sponsors, and requirements for extra credits to cover lags can be a burden for buyers. In addition, if the credit release schedule or extra credit requirements are variable and set by the district engineer, they can result in additional uncertainty and risk. Credit release is not automatic and is dependent on the USACE and IRT determination of whether the bank has met set performance standards. Although allowable, the gap in environmental benefits (between impact and mitigation) resulting from a time lag is not always incorporated into transactions. This reduces uncertainty for buyers and sellers but can result in an overall loss of ecological function and a loss of public goods and benefits (Robertson 2006; Gardner 2011).

The same watershed and credit requirements that may help to reduce uncertainty about natural variability for banks may create market uncertainty and risks for permittees (buyers). For example, in some districts only those permittees with impacts within the watershed (service area) and of the same type as the credits available in a bank would be able to purchase credits from that bank. Some districts allow permittees to use credits from banks in adjacent watersheds if the permittee purchases the credits at a higher ratio (e.g., 2:1). Banks will not be established in areas expected to have little development and thus low demand for credits. In these watersheds, permittees may be forced to undertake their own mitigation unless ILF programs are operating in their region. As noted above, when permittee-responsible mitigation is used, the liability and risks remain with the permittee.

Because functional measurement methods lack standardization, their use could create additional risk for permittees and banks if it increases crediting uncertainty. Although adjustment of accounting ratios may reduce uncertainty in achieving environmental outcomes, it may create market uncertainty in those cases in which the setting of ratios is at the discretion of the district engineer rather than based on a standard accounting framework. In this case, permittees can be faced with uncertainty about how their impact will be assessed and how much compensatory mitigation will be required. Similarly, mitigation banks may face uncertainty about how their sites will be assessed and how much credit they will receive.

The mechanisms described above may help to reduce the natural variability between the impact site and the mitigation site as well as scientific uncertainty in assessing the functions at both sites. However, without monitoring to match the functions lost from impacts with the functions gained from mitigation, it will be impossible to determine if overall functions were gained or lost. Programs are not designed to directly compare impact assessments with mitigation site assessments. Consequently, potential losses or gains in ecological benefits are highly uncertain. The studies that have assessed the function of wetland and stream mitigation suggest that restored and created sites are not generating the same functions as

reference sites and in some cases are not meeting ecological performance standards (Burgin 2010; Micacchion et al. 2010; Moreno-Mateos, Power, Comin, and Yockteng 2012; Palmer, Hondula, and Koch 2014; Palmer and Filoso 2010; Palmer, Menninger, and Bernhardt 2010; Suding 2011; Reiss, Hernandez, and Brown 2009; Wall and Stevens 2014).

Failure to fully compensate for lost functions due to technical uncertainties is not a risk to the buyer or seller once credits are sold. Neither is held liable for a failure of a bank to effectively compensate if they are meeting the requirements of their instruments.[8] The seller does, however, hold risk for uncertainties related to banks that are under development. If site establishment does not proceed as planned, banks can face unexpected costs. The remaining risk of insufficient compensation thus becomes a risk that the program will fail to achieve no net loss objectives and a risk that the public will bear losses to the public goods they hoped to protect through the Clean Water Act.

Extreme Events

Droughts and related fires and perhaps saltwater intrusion could significantly damage the development and restoration of wetland vegetation and habitats. Large storms (e.g., hurricanes, tornados) and floods could scour and undermine stream restoration and perhaps even change the course of a river. And restored coastal aquatic systems could similarly be damaged by large storm surge events. Some systems may recover naturally, and others may require significant restoration. In the worst cases, in which a barrier island has moved or a river has jumped channels, systems will no longer be viable mitigation sites.

Management Strategy:

- **Resilience:** Mitigation banks could be more resilient to future risks than smaller and more isolated permittee-responsible sites given that bank sponsors often have greater expertise in restoration and creation of aquatic systems, concerns over reputational risk, and use large connected sites.

- **Force majeure:** Mitigation bank (as well as ILF and permittee-responsible) agreements include *force majeure* provisions that limit bank liability and responsibility for mitigation project failures attributed to natural catastrophes such as flood, drought, disease, and pest infestation (Nebraska Department of Roads 2012).

- **Adaptive management plans and financial assurances:** If damage does not rise to the level of force majeure, the bank sponsor may be obliged to make repairs using financial assurances. If damage does rise to the level of a force majeure, the bank sponsor will decide whether to repair the damaged bank and sell additional credits.

Effect of Management Mechanisms on Risks and Liability:

Loss of compensatory functions due to extreme events is not a risk to the buyer because all liability is held by the bank. *Force majeure* provisions limit banks' liability for credits once they are sold; however, these provisions typically will not allow unreleased (unsold) credits to be used in the future if the project

[8] USACE and DOI contend that bank instruments are not contracts but an excision of regulatory authority like permit issuance (Steve Martin, pers. comm.).

is negatively affected by an extreme event. Therefore, the bank sponsor will still hold risk relating to prospective credits in its bank. The loss of functions in sold credits will remain a risk for the program in that the program may fail to achieve its no-net-loss objective as well as a risk for the public given the potential loss of the public benefits wetlands and streams provide.

Behavioral Uncertainty

Given that wetlands and streams are difficult to restore and even more difficult to create, significant expertise and maintenance may be required to establish functional sites, increasing the likelihood of failure due to human error or inability to provide needed development or management over time. This risk of failure particularly arises when inexperienced landowners and other entities undertake mitigation projects.

Management Strategy:

Under the 2008 rule, mitigation plans for all wetland and stream compensatory mitigation projects must contain monitoring requirements, a maintenance plan, a long-term management plan, an adaptive management plan, and financial assurances (see Appendix A), all of which help to manage risks arising from extreme events and behavioral uncertainty.

- **Monitoring:** Given uncertainty during the development of a mitigation site, the district engineer may (but is not required) to conduct site inspections on a regular basis during the monitoring period. This period should be sufficient to demonstrate that the site has met performance standards but cannot be fewer than five years (33CFR332.6). A longer period is required for slow-developing systems (e.g., forested wetlands, bogs). Whether and when to make site visits and whether to shorten or lengthen monitoring requirements is up to the discretion of the district engineer.[9]
- **Scheduled credit release:** Another mechanism used to reduce behavioral uncertainty during development of mitigation sites is a release schedule for credits. Often some proportion of credits are released when the full bank plan is approved, and more are released as agreed-to-performance standards are achieved. The banks receive no additional credits until standards are achieved. In this way banks get some revenue and some certainty of return, and some protection is in place to reduce project failures.

- **Permanent protection:** To address longer-term uncertainty, banks require what is called a "site protection instrument," which clarifies the legal ownership of the site. Most often this instrument involves a permanent conservation easement held by a non-profit land trust, government, or tribal conservation trust (qualified easement holders). Most organizations that become easement holders are interested in taking responsibility only for large, ecologically valuable parcels, which constrains where easements can be used. The easement transfers responsibility for ensuring that

[9] In a review of this paper, David Olson of the U.S. Army Corps of Engineers said, "The key to successful compensatory mitigation is monitoring, evaluating the monitoring data, and if the compensatory mitigation project is not developing in the manner anticipated during planning and approval, implementing remediation or adaptive management measures to fix the problems. The compliance component is critical; otherwise the mitigation provider won't have that much incentive to do what he or she agreed to do."

the project is legally protected to the easement holder and reduces the likelihood of permanent encroachment or of incompatible activities. The deed restrictions are usually held by the landowner. Easements create a risk for landowners if land value shifts resulting in less compensation to the landowner than the land is now worth.

- **Management and maintenance plans:** Banks are required to have a long-term plan for management and maintenance after performance standards have been achieved. That plan can include long-term financing mechanisms, which can be funds set aside in endowments, escrows, or trusts. A non-wasting endowment can be held by a third party on the basis of the long-term management outlined by the regulatory agency. The more active the management need, the higher the endowment. Although long-term management and maintenance plans are designed to reduce uncertainty about environmental outcomes, placing the burden on mitigation banks, they also provide a framework for limiting banks' liability to what is agreed to in site plan documents. These plans and endowments can also be used in recovery of sites damaged by extreme events.

  Banks are also required to have an "adaptive management plan" in place. This plan is used to address management risks through contingency fees built into the budget by the mitigation provider. Contingency fees are a percentage of the overall project cost. Adaptive management plans are required in addition to long-term stewardship. In theory, an adaptive management plan could help regulators and banks plan for and react to changes that affect a bank's function. It may include credit adjustments given failures in performance, or it could include modifications in monitoring and requirements for remedial action. The development of the adaptive management plan may help bankers think through and consider potential future risks and build increased resistance or resilience built into project designs or maintenance.

- **Assurances:** Banks are required to provide "financial assurances" to cover uncertainty before the mitigation bank site is fully established. Assurance alternatives include performance bonds, escrow accounts, casualty insurance, and letters of credit (Scodari, Martin, and Willis 2011).[10] All these alternatives need approval from the district engineer.

Effect of Management Mechanisms on Risks and Liability:

The use of risk management mechanisms should reduce behavioral uncertainty during site development and long-term maintenance. However, mitigation banks that face both a delayed credit-release schedule based on the timing of their projects' delivery of benefits and requirements for assurance to cover project costs may view this double coverage of risk and as a barrier for bank development.[11] The risk of failures during project development become liabilities held by the mitigation bank; however, these liabilities should be constrained by the requirements set forth in planning documents. Where prevalent, district engineer discretion may increase uncertainty in monitoring requirements and costs for bankers. And as

[10] In a review of this paper, Steve Martin of the U.S. Army Corps of Engineers Institute for Water Resources elaborated on the choices: "Currently, letters of credit and performance bonds are most popular. Many districts like Sacramento, Seattle, and Chicago will not accept performance bonds as financial assurances because of their experiences in dealing with disputes with sureties over claims. Casualty insurance is a new product and has been approved for use in 13 districts for less than 50 banks. Some districts have expressed concern about their ability to successfully pursue claims and about the claims adjustment process."

[11] David Urban (Ecosystem Investment Partners), telephone conversation with author, August 10, 2015.

noted above, the requirement for permanent site protection is a responsibility for easement holders and can be a risk for landowners, depending on the potential for shifts in opportunity costs. If a bank fails to deliver anticipated ecological function, the regulator can use litigation to force the bank to perform (Gardner 2011), but the regulator may also be held liable if it issued a permit for an impact that is not adequately offset (BenDor and Riggsbee 2011).

Regulatory Uncertainty

Overall, federal and state mitigation rules are clear, and USACE district approaches to bank requirements and crediting are transparent, yet mitigation bankers can face uncertainty about how the rules are applied and the approaches are implemented.[12] First, many final decisions about mitigation bank plans and crediting are at the discretion of the district engineer, and each district engineer can apply the rules differently. District engineers have discretion over what types of mitigation activities will be allowed and may make their decisions on a case-by-case basis rather than on the basis of predefined standards. Many districts currently require no compensatory mitigation for stream impacts, so there isn't much of a market for those types of credits in those districts unless a state regulatory agency imposes stream mitigation requirements on the activities it regulates.[13] In addition, state laws (e.g., Florida State Law 373.4137, F.S.) and local ordinances (e.g., Lake County Stormwater Management Commission, Illinois, 2013) can affect how a mitigation bank must be designed and the credits it receives, and thus can generate additional regulatory uncertainty. Bank sponsors face uncertainty if regulations or court decisions alter program implementation by reducing the scope of jurisdiction or the types of activities that require mitigation or by reducing the scope of application or types of mitigation allowed.

Currently, proposed changes to the federal definition of U.S. waters generate uncertainty for mitigation banks. The new definition may expand the range of waters that fall under federal jurisdiction and the mitigation requirement in the 404b provision of the CWA in some regions (U.S. EPA and USACE 2014). If so, demand for mitigation could increase, but existing mitigation sites might also be made U.S. waters. If a mitigation bank fails to sell its credits and wants to redevelop its land, it may require a 404 permit and have to buy mitigation to compensate for any impacts to the stream or wetlands it has already restored or created.

Management Strategy:

To reduce regulatory uncertainty, many states have adopted standard operating procedures for the debiting and crediting process, but many still have not. Risks from shifting federal and state regulations are relatively hard to manage.

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[12] For an example of the variability in rules and in their application, see the following: mobile district guidelines on restrictive covenants and model conservation easements, http://www.sam.usace.army.mil/Portals/46/docs/regulatory/docs/Restrictive%20Cov/Restrictive%20Covenant%20I%20Conservation%20Easement%20Instructions.pdf; mobile district guidelines on mitigation, http://www.sam.usace.army.mil/Portals/46/docs/regulatory/docs/2009%20Stream%20SOP%20with%20Correction.pdf; the Wetland Rapid Assessment Procedure for the South Florida Management District, http://www.sam.usace.army.mil/Portals/46/docs/regulatory/docs/WRAP.pdf; and the Texas Rapid Assessment Method, http://media.swf.usace.army.mil/pubdata/environ/regulatory/permitting/applicationforms/TXRAM_Wetlands_and_Streams_Modules_Version_1-0_Final_Draft.pdf

[13] David Olson of the U.S. Army Corps of Engineers, in a review of this paper.

Effect of Management Mechanisms on Risks and Liability:
Standard operating procedures can significantly reduce uncertainties and potentially reduce costs faced by bankers by increasing transparency and certainty.

Market Uncertainty

Changes in where and what kind of mitigation is needed can affect demand for bank credits. The primary risk for banks is that demand will be insufficient due to some shift in the scale or location of development activities (e.g., road construction), in regulation or rules, or in competition from ILF programs or other banks. In addition, timing can raise issues. Demand for credits can precede credit availability. Even approved banks often have no credits for release when permitted impacts occur.

For the regulated permittee, the primary risk is that bank credits and ILF programs are not available in the necessary service area, potentially slowing project permitting and construction and likely requiring the use of permittee-responsible mitigation. Permits are issued faster when credits are used from approved banks, providing significant permit time savings for permittees (Birnie 2015).

Management Strategy:

- **Allow purchase and sale outside service area**: If demand for credits is constrained to a small service area, the size and number of banks available to meet this demand could also be constrained. Additionally, banks may have little ability to respond to shifts in demand if they are constrained to operating only in their own service area. If buyers and sellers (banks) are allowed to use neighboring service areas, even if they operate at a comparatively high trading ratio (e.g., 2:1 rather than 1:1), market risks could be reduced. However, the natural variability and disconnect in flow of benefits between the impact and the compensation sites could increase, potentially resulting in programmatic risk and loss of public benefits.

- **Combined wetland and species credits**: If a wetland is also habitat for an endangered species and the bank meets requirements for conservation banks, which are similar to those for wetland banks, they can sell species credits as well as wetland credits (Bean, Kihslinger, and Wilkinson 2008). Although they can sell the credits into two different markets, they cannot sell the same credit/acre twice (U.S. EPA 1995).

- **Reduce ILF competition**: Another potential source of market uncertainty is competition from ILF programs. Although the 2008 rule requires in-lieu fee programs to charge full cost, factors such as complexity in determining full cost because of geographic and temporal variability could make rates lower than those available through private mitigation banks. If so, the market for bank credits in those areas could be undermined, limiting the development of banks or the use of existing ones, even where there is a preference for banks. If, instead, ILF prices are set higher than market price, they could provide an alternative for permittees in areas where banks are not available, without creating market uncertainty for banks.

- **Registry/exchange**: Until recently, 404 mitigation programs had no tracking system for sharing data on credits. The RIBITS system set up by the USACE now collects data on mitigation banks

and ILF program projects, including number of credits and availability (USACE 2015). The database, although missing a few programs and banks, is fairly complete. To avoid interference with the market and transactions, RIBITS was not set up as a market exchange. No exchanges with data on demand for credits or prices exist. The lack of transparency in credit pricing can increase risk and create a barrier for new entrants into regional markets. Where in place, ILF programs can provide some indication of pricing, but otherwise new entrants will have to develop their own estimates (Coleman 2015).

Effect of Management Mechanisms on Risks and Liability:
Loosening service area restrictions can reduce risks for buyers and sellers by giving permittees flexibility in where they can find bank credits and giving banks flexibility in where they can sell credits. However, loosening these restrictions may result in shifts in the types or flow of benefits between the impact and compensation sites and may result in programmatic risk and dislocation of public benefits (e.g., hot spots of impact, with distant areas used for mitigation) (BenDor, Hotles, and Doyle 2009; Ruhl and Salzman 2006). In addition, allowing wetland banks to sell species credits benefits both sellers, by reducing the risk of insufficient demand for credits, and buyers, by increasing the possibility that credits will be available where needed. Increasing costs for ILF credits above market prices can reduce risks for banks, which may result in additional bank credits available for buyers. But permittee risk is relatively unchanged. If either bank or ILF credits are available, permittees can avoid permittee-responsible mitigation and pass on liability to bank sponsors or ILF programs.

An electronic market exchange with clarity on expected demand and credit prices could, in theory, reduce risks for both buyers and sellers, particularly new entrants; however, it may allow landowners to raise prices, affecting ILF and banks' ability to purchase sites and easements for mitigation at competitive prices.

Managing Remaining Risk
As described above, the 2008 rules have many provisions that may help to reduce the risk that compensatory mitigation projects hold for buyers, sellers, and the environment. Many of these provisions require detailed plans (e.g., monitoring and adaptive management) to be specified up front. The rules also helped to define equivalent standards applicable to all forms of mitigation but left room for regional variation in technical and crediting methodology. In those states that have them, clear standard operating procedures have created greater certainty for mitigation banks about potential risks and the number of credits they will receive (e.g., scheduled credit release plans).[14] However, a variety of risks remain. Buyers and bank sponsors have set up mechanisms outside regulatory programs to manage these risks. In addition, bankers use their own market research on regulatory and market uncertainties and risks to invest strategically and reduce foreseeable risk (Hook and Shadle 2013; BenDor and Riggsbee 2011).

Vertically Integrated Program
Vertically integrated mitigation programs require those needing permits and those creating mitigation credits to be closely coordinated and overseen by one organization. For example, the Division of Mitigation Services (formerly the Ecosystem Enhancement Program) in North Carolina, an ILF program,

[14] Plan authorization determines potential credit yield. Actual yield may vary and depends upon ecological performance (Steve Martin, in review comments on this paper provided to the author August 15, 2015.)

has a full-delivery option whereby it acquires credits to meet mitigation needs statewide for both the public sector. The division acquires compensatory mitigation to meet the needs of the North Carolina State Department of Transportation (DOT), which needs credits to ensure that its projects progress smoothly. Because the buyer is affiliated with the regulatory permitting authority, conflicts of interest can result (Environmental Law Institute 2002; Gardner 2000). However, vertically integrated mitigation programs reduce risks for the regulated buyer (DOT) by ensuring that mitigation will be available when and where they need it. Such programs can be designed so that the institutional buyer oversees the purchase of credits from private banks instead of creating its own ILF mitigation, which may lower the potential for market risks. The North Carolina program includes this option as well.

Transferring Risk through Contracts

Buyers can set up purchase agreements with banks for guaranteed delivery of a specified number of credits at a specified price. Although this arrangement provides up-front capital to the project developer, it also transfers significant liability to the bank, which must meet its contract agreement even if some of the uncertainties discussed above reduce the credits it generates or raises the cost at which the credits are profitable. Buyers can sue sellers for fines or penalty costs as well as for undelivered credits (requiring the seller to provide the credits through generation or purchase) if the seller violates its contract.

Private Buffers

Mitigation banks or brokers or ILF programs can use buffers to manage all sorts of risks. The seller may build in extra buffers to each project as its own form of risk reduction.

Diversified Project Portfolios

Sellers can also address risks by having diversified portfolios of banks (a mixture of wetlands and streams located in different service areas) to hedge risks related to market and regulatory uncertainty and extreme events.

Insurance

In theory, insurance could help reduce risks for banks and would be an acceptable form of financial assurance for mitigation (Scodari, Martin, and Willis 2011). Ecosystem Insurance Associates and Lexington Insurance both have insurance products that can function as financial assurance for banks.[15] They are accepted as an assurance mechanism in 13 districts. In some cases, state laws limit the use of such tools (e.g., Florida).[16] Some investors in mitigation banking find insurance to be a useful tool for transferring risk.[17] Others consider it an expensive alternative to other forms of financial assurance.[18]

Programmatic Adjustments

Opportunities for programmatic adjustments to address failures to meet regulatory objectives (in this case, adjustments supporting no net loss) occur when districts and states update their assessment methods for quantifying impact and compensatory mitigation sites and when national regulatory guidance is reviewed

[15] See http://www.eco-ins.com/ and http://lexins.co/1/lexHS_lexEcoBank.pdf.
[16] David Urban (Ecosystem Investment Partners), telephone conversation with author, August 10, 2015.
[17] David Urban (Ecosystem Investment Partners), telephone conversation with author, August 10, 2015.
[18] George Kelly (RES), telephone conversation with the author, March 12 2015

and revised. The 2008 rule that updated how wetland and stream mitigation was conducted is one example of a programmatic adjustment intended to improve outcomes.

Improving programs necessitates understanding the effectiveness of mitigation programs and actions the government takes to address no net loss. Understanding of the ecological outcomes of each impact and mitigation site is limited, making it difficult to evaluate where and how aquatic functions are being lost. Some information on the national status and trends of aquatic systems is available from a national sampling program, the National Wetlands Inventory (NWI), according to which national wetland losses outpaced gains between 1998 and 2004; the program estimated the net wetland loss at 62,300 acres between 2004 and 2009 (Dahl 2011). Recent studies on stream restoration and wetland mitigation suggest that environmental objectives are not being fully achieved (Micacchion, Gara, and Mack 2010; Wall and Stevens 2014; Palmer, Hondula, and Koch 2014; Moreno-Mateos, Power, Comin, and Yockteng 2012). These studies suggest a need for better adherence to ecological performance standards (Micacchion, Gara, and Mack 2010), along with review and updating of particular mitigation methods, structure assessment procedures, and monitoring periods, which may not be sufficient (Stefanik and Mitsch 2012; Wall and Stevens 2014). The Environmental Law Institute has developed a national evaluation of compensatory mitigation sites that could increase understanding of which program adjustments could increase ecological success (Fennessy et al. 2015).

Conservation Banking

The Endangered Species Act of 1973, which is administrated by the U.S. Fish and Wildlife Service (FWS) and the National Marine Fisheries Service (NMFS), makes it unlawful for a person or the federal government to "take" a listed animal species without a permit (Section 7 and Section 10). *Take* is defined as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or to attempt to engage in any such conduct" (50 CFR 17). There are significant penalties for harming endangered species.[19]

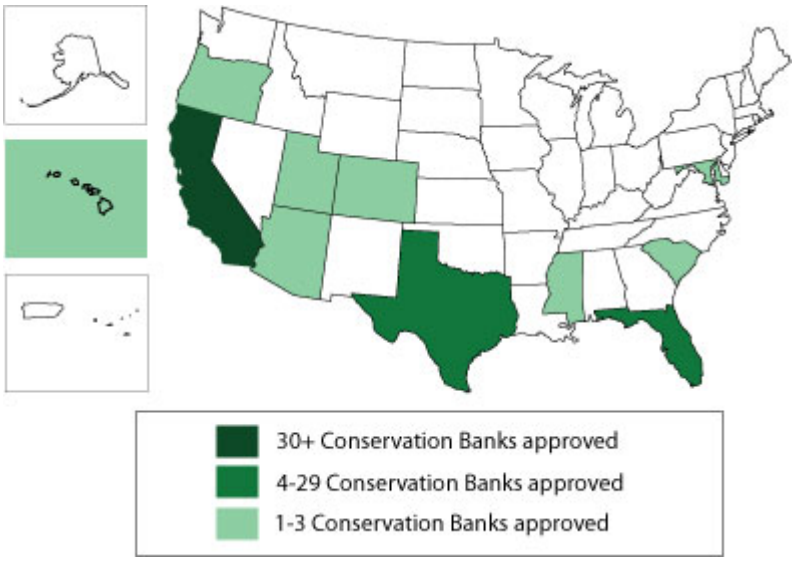
To address "incidental take" that occurs in the course of development, federal and non-federal actors can use a range of mechanisms. These mechanisms include acquisition of credits from conservation banks, which are permanently protected and managed to offset adverse impacts to a listed or at-risk species elsewhere at an impact site. Conservation banks are eligible to provide mitigation for federal actions under Section 7 consultations or for private actors under Section 10 permitting for habitat conservation plans (HCPs).

The idea of conservation banking grew out of wetland mitigation banking. However, wetland mitigation focuses on replacing lost wetlands functions, whereas conservation banks are designed to preserve species habitat, mitigating losses of habitat elsewhere (U.S. DOI 2003). As a result, conservation banks can be focused on protection and management of existing habitat that is critical for the species rather than restoration or replacement of acreage.

Bank sponsors, whether landowners, NGOs, state agencies, or mitigation banking businesses, can enter into conservation bank agreements with the U.S. FWS and receive species credits by permanently protecting and managing their lands for one or more covered species. Lands used for ranching, farming or timber harvesting as well as restored lands or retired croplands and riparian buffers can all serve as conservation banks if they are managed for species. Banks can be established with U.S. FWS for listed or candidate species (U.S. FWS 2012). Banks are now established in many states but are most prevalent where state counterpart laws require parallel mitigation for species impacts, as is the case in California (Figure 3). Conservation banks are less prevalent than wetland and species mitigation banks, in part because the provision for conservation banks is newer and perhaps because conservation bank sponsors face greater uncertainty and risk.

[19] For crimes involving endangered species, violations of the Endangered Species Act may be punished with fines up to $50,000, one year imprisonment, or both; for crimes involving threatened species, violations may be punished with fines up to $25,000, six months imprisonment, or both (16 U.S. Code § 1540 - Penalties and enforcement).

Figure 3. States with conservation banks from RIBITS (USFWS website)



Bank sponsors can profit from selling credits to those who need to compensate for impact to species. By creating a conservation easement, they may also see financial benefits from reduction of real estate taxes through conservation tax credits. For developers who are causing species impacts, use of species credits from banks can save time and money and provide regulatory certainty.

Conservation banks are a form of advance mitigation, defined by Greer and Som (2010) as "the proactive acquisition and restoration of lands for mitigation in advance of anticipated future impacts." Such mitigation is viewed as beneficial because it may potentially reduce funding requirements for ESA compliance through lowered mitigation obligation, decreased overall permitting time, and decreased monitoring costs achieved through economies of scale. Advance mitigation increases the efficiency of project approvals and the certainty of cost estimates, and it takes advantage of conservation opportunities before important land is lost to conversion (Greer and Som 2010).

Who Is at Risk and What Risks Do They Face?

Developers and landowners who through development or management of non-federal lands face an unavoidable incidental take (after already attempting to avoid and minimize impacts) can obtain an incidental take permit, provided they prepare a habitat conservation plan (HCP) that specifies how impacts will be minimized and mitigated to the maximum extent practicable. Use of conservation banks can be one option under Section 10(a)(1)(B) of the ESA. Under Section 7(a)(2), they are also an option for federal actors, albeit with some differences in specifications.

When credits are purchased from conservation banks, all liability for mitigation of species impact transfers to the banks. Bank sponsors bear the responsibility and risks inherent in preserving and restoring habitat that meets requirements laid out in agreements with the U.S. FWS and any other state or local agency involved. The agreements are species specific and thus different for each bank. However, in California, templates for banking agreements increase efficiency and consistency.

Landowner roles within conservation banking vary. Landowners may be able to sell lands to conservation bank sponsors removing themselves from any program risks. However, they may act as the bank sponsor themselves or work with a bank sponsor and share in profits from credit sales. Landowners can hold opportunity cost risks if alternative values for their lands increase above the level of compensation they have received. If they are the bank sponsor, landowners will also share in the risks associated with being a signatory to a conservation banking agreement.

When, despite risk management tools built into bank agreements, conservation banks fail to provide habitat necessary to support endangered species' survival, the public bears the loss—the risk of which is termed programmatic risk.

Information provided here for conservation banks comes almost entirely from the 2003 guidance from the U.S. Department of the Interior (DOI) (U.S. DOI 2003). The U.S. FWS is expected to release revised guidance in 2016 with regard to all forms of mitigation for species impacts. Conservation banking agreements are accessible through USACE's public database (RIBITS).

Five Types of Uncertainty and How They Can Be Managed

Five types of uncertainty lead to risks for regulators, landowners, and buyers and sellers of conservation bank credits. Federal guidance includes a variety of management mechanisms that may help to manage these uncertainties.

Technical Risk

Natural Lag Time

When conservation banks are used to preserve existing species habitat, time lags are less of an issue than when creation and restoration are the primary activities. But when site restoration and management are required by banks that need high-quality habitat, time lags will be important to consider in bank design and development, which is accomplished in agreement with the U.S. FWS.

Management Strategy:

Require verification before sale: The U.S. FWS can require verification of restoration outcomes before releasing credits for sale (U.S. DOI 2003), creating uncertainty and costs for credit sellers and buyers, as is the case with wetland and stream projects.

Natural Variability

Conservation banks are designed to conserve habitat for a long time over large areas that are constantly facing change (Camacho, Taylor, and Kelly 2015). This natural variability as well as variability between impacts and credits must be managed.

Management Strategy:

- **Landscape plans and recovery plans:** Using the latest scientific information on landscape and species recovery priorities in the siting of banks allows banks to address natural variability that could affect their long-term viability.

- **Phased authorization of bank area:** The U.S. FWS can prioritize the areas of greatest ecological value by using a phased approach, allowing the bank to offer credits in the best sites first and in other sites later if demand is sufficient (U.S. DOI 2003).

- **Variable weighting of credits:** The U.S. FWS can weight credits and debits for species differently depending on where they occur if the quality or connectivity of habitat varies (U.S. DOI 2003). For example, a high-quality habitat might be allowed one credit for one acre, whereas a lower-quality habitat, perhaps an edge, might be allowed one half credit for one acre. This approach helps to capture some of the natural variability in habitat quality over a landscape. Weightings of a site's relative importance can vary to account for changes in habitat and species preferences driven by fragmentation and climate change.

- **Adapting to climate change:** The siting of banks and of service areas (areas in which credits may be used to offset project impacts) are based on current understanding of species needs and ranges. Climate change is generating significant uncertainty about how these needs and ranges will vary over time. Because species ranges are likely to shift, bank design could consider connectivity to potential future habitat. New habitat exchanges with temporary instead of permanent areas of protection and habitat management is a new model being developed which could allow for some shifting of habitat priorities over time.

Scientific Uncertainty

Conservation banks are designed to meet the needs of specific species. Uncertainties about how best to manage habitat to support the preservation and recovery of species will require the use of expert opinion and, in some cases, new research. A 2001 study (Harding et al. 2001) reported that quantitative population estimates could be located for only 10% of the examined species and that for 42% of the species, data and analysis were insufficient for the authors to determine how predicted take might affect populations.

Management Strategy:

Requiring the use of "sound scientific principles" (U.S. DOI 2003) can leave uncertainty about species outcomes given scientific uncertainty regarding conservation bank design and management. Other strategies are needed to address these uncertainties.

- **Using simple measures to set credits**: To set the number of credits for a bank, the method can be as simple as one credit equals one acre of habitat or one nest site or family group (U.S. DOI 2003). The typical approach is to create a habitat equivalency area between the impacted site and the conservation site. Credits are not typically tied to species numbers, because they are difficult to count. Moreover, when the number of credits for a bank is based on species numbers, natural variability in species populations can pose a risk for both the species and the banker. When the number of credits a bank receives is based on the current year's species population, it could be set low or high relative to the average or expected species population level. But data on average annual population levels often do not exist and require time and money to collect.

- **Delayed release of credits**: If it is important to use species numbers and data are not available, regulators can set an initial allocation of credits on the low side on the basis of available

information and release additional credits, perhaps in additional locations, on the basis of future performance according to agreed measures (U.S. DOI 2003).

- **Alignment of bank siting and management plan with conservation plans:** To achieve the best ecological outcome for a species, the U.S. FWS will evaluate banks on the basis of the alignment of the banks' siting and management programs with a U.S. FWS recovery plan or other conservation plan (U.S. DOI 2003).

- **Monitoring and adaptive management:** After an in-depth review of HCPs by a group of academic experts found that lack of information on species in the plans generated significant uncertainty in species survival (Watchman, Groom, and Perrine 2001), guidelines to increase monitoring, data collection, and adaptive management were adopted (U.S. DOI and U.S. DOC "Federal Register" 2000). Similar guidelines are found in the conservation banking guidance (U.S. DOI 2003).

Effects of Management Mechanisms on Risks and Liability:
Where required, constraints on credit releases or phased authorization of bank areas can be a burden on bank sponsors. Given that there are no standard accounting practices for species habitat impacts and credits, there will be uncertainty about how impacts and credits will be measured and thus about how much credit will be required by permittees and produced by banks. Uncertainty about the credit release schedule and credit weighting could potentially generate significant risk for banks.

If landowners maintain easements on their properties for banks, they face a risk of increased opportunity costs if land or agricultural values rise. The use of temporary credits in newly developing habitat exchanges can help reduce this risk for landowners.

The use of service areas, though valuable for ensuring that impacts and bank credits match in terms of habitat quality, imposes uncertainty for banks, by limiting the potential demand for their credits, and for buyers, by constraining the type of credits they can use.

Extreme Events

Management Strategy:

- **Resilient design/bank siting:** Bank sites are selected to reduce threats to species and habitat. Siting considerations may include conservation of large unfragmented habitat blocks, connectivity to other habitat, and size sufficient to maintain a viable population. The species recovery plan can be used to identify these threats where it is available and up to date. If it is not available and up to date, the U.S. FWS will develop an alternative strategy (U.S. DOI 2003).

- **Force majeure:** According to federal guidance, conservation banks are not held responsible for "acts of nature that are unforeseen, or foreseeable but unpredictable, such as earthquakes, floods, or fires" (U.S. DOI 2003). Agreements include *force majeure* provisions that limit bank liability

for project failures attributed to natural catastrophes (U.S. FWS 2008).[20] These agreements could reduce risks to banks (sellers) for already-sold credits, and they may limit the scope of funding required from a bank's endowment to address damages to the bank's remaining credits.

- **Remedial measures:** Federal guidance specifies that bank agreements should include procedures for implementing and funding any necessary "remedial measures" for "acts of nature" after the sale of credits and for temporarily suspending the release of credits pending remedial action for such acts prior to the sale of credits (U.S. DOI 2003).

Effect of Management Mechanisms on Risk and Uncertainty:
Federal guidance incorporates mechanisms to manage for the risk that extreme events pose for conservation bank design. Although federal guidance suggests that banks are not held responsible for extreme events and limits their liability, it states that bank agreements should include procedures for "remedial measures" if such events occur. These procedures may place a burden on the banks both for sold and unsold credits if the events occur, but this risk appears to be bounded by the details of bank agreements.

The U.S. FWS is also exploring the idea of reserve credit accounts—credits set aside to offset force majeure or other unforeseen events.

Behavioral Uncertainty

A wide variety of mechanisms, similar to those used in wetland and stream mitigation, are used to address behavioral uncertainty regarding restoration or ongoing management requirements for conservation banks.

Management Strategy:

- **Monitoring plans:** All banks are required to have a monitoring program specific to the needs of the species being protected—a program that is funded, if necessary, by a bond "equal to the present value of the management costs" or some other form of surety. The monitoring is the responsibility of the bank sponsor and is overseen by a conservation bank review team that supervises the establishment and operation of the bank.[21]

- **Delayed credit release:** The U.S. FWS can require that banks have restoration activities and maintenance in place and have agreed to measures of success before credits are released to them (U.S. DOI 2003). Banks could receive a reduced number of credits or no credits if they underperform (U.S. DOI 2003).

[20] Buyers have already transferred liability to the banks and therefore are no longer are liable if an event happens after a sale of credits.
[21] The conservation bank review team is "an interagency group of Federal, State, tribal and/or local regulatory and resource agency representatives that are signatory to a bank agreement and oversee the establishment, use, and operation of a conservation bank" (U.S. DOI 2003).

- **Permanent protection:** Conservation banks require permanent protection of the bank site through fee title or conservation easement, with land use restrictions set in perpetuity. The entire bank or project phase is protected as soon as a single credit is sold, eliminating future fragmentation of that habitat (U.S. DOI 2003). The site protection instrument must be held by a third party, not the bank sponsor or landowner, who has rights of enforcement and who is capable of maintaining the site.

- **Endowed maintenance and adaptive management plans**: For ongoing maintenance activities (prescribed burning, trespass prevention, and so on), conservation banks require adaptive management programs and funding for them is part of the banks' endowment (U.S. FWS 2008).

- **Dispute resolution:** Conservation banks also require a dispute resolution mechanism.

- **Buffer requirements:** Species banks do not know how neighboring landowners will manage their lands and what the effects may be on species survival. One way to address this uncertainty is to include buffer area requirements in the design of banks (U.S. DOI 2003). Although bank owners are not liable for actions taken by neighboring landowners, such requirements can increase the cost of both the bank and the credits it sells, especially when buffer habitat cannot be sold for credit (U.S. DOI 2003).

- **Long-term stewardship fund**: A fund for required long-term stewardship is supposed to be non-wasting and fully funded by a date certain to cover identified long-term management plans. There is a risk that a bank sponsor will not be able to fund the endowment due to underperforming bank assets. Resource agencies typically attempt to ameliorate that risk by funding the endowment through early credit sales and initial contributions.

Effect of Management Mechanisms on Risk and Uncertainty:
Many of these mechanisms place an upfront burden on bank sponsors to endow and provide surety for monitoring and maintenance, to obtain permanent protection of lands, and to find a third party capable of maintaining the bank and covering the cost of a buffer. Some of these costs can be shifted to credit buyers through credit purchase prices, but until credits sell, the burden on bank sponsors can be significant, particularly if there is great uncertainty about the timing, number, or value of credits they will sell. That upfront burden may be one reason that conservation banks outside of California, where state law increases certainty for banks, have been slower to develop.

As noted above, if landowners maintain easements on their properties for banks, they face the risk of increased opportunity costs if land or agricultural values rise. The use of temporary or term credits in newly developing habitat exchanges can help reduce this risk.

Regulatory Uncertainty

Because every species is different, and each U.S. FWS district has different expertise and experience, every conservation bank is different, creating significant regulatory uncertainty about how many credits banks will have to sell when and to which parties (set by service area). Every adverse impact is evaluated

individually, and different ratios for required mitigation credits can be used, depending on the relative quality of the affected site and the bank site (U.S. DOI 2003).

Management Strategy:

Predetermining credits: If a bank is providing preservation, the number of preservation credits available can be determined at the time the banking agreement is established (U.S. DOI 2003). The agreement should also specify credit-determination methods, including any weighting based on site quality or location (U.S. DOI 2003).

Species-specific banking templates: California, where most conservation banks are located, has templates that significantly reduce uncertainty (U.S. FWS 2015b). For any area, once a bank is established for a species, subsequent banks follow that agreement as sort of a species-specific template. For some species, publicly available mitigation guidance identifies service areas and credit methods (U.S. FWS 2015a, 2015c, 2009a, 2009b).

Effect of Management Mechanisms on Risk and Uncertainty:
Bank agreements are expected to specify how crediting will work, providing some certainty for the bank sponsor as well as indicating potential supply to buyers. Bank developers can incur significant costs before bank agreement details are specified and the profitability of their credits are made clear. Waiting for establishment of a bank and a banking agreement that defines the service area, credit and debit accounting, and certification of credits can also generate uncertainty for those facing incidental take of species (the buyers).

Market Uncertainty

Regulatory uncertainty is a significant risk for sellers. It makes the number of credits they'll have to sell difficult to predict. Similarly, regulatory uncertainty in the form of variable enforcement of the ESA makes demand for credits difficult to predict. Lack of consistent enforcement can occur even within a state; in Texas, for example, enforcement is much more robust in the Austin region than in the Dallas region. Because an entire bank or phase of a bank is protected as soon as a single credit is sold (U.S. DOI 2003), bankers face the risk that expected demand is not realized and is insufficient for them to break even or profit. In addition, if the required non-wasting endowment, which covers long-term stewardship, is not filled through the sale of credits, banks may be required to ante up remaining funding. Often a portion of the sale of a credit goes toward covering the endowment. As a result, banks are unlikely to be developed if uncertainty about demand is significant.

Where banks are not already established, permittees (buyers) can face uncertainty about the timing and amount of credits a prospective bank will provide.

Management Strategy:

- **Service area:** Bank agreements may impose specific constraints on where credits can be sold (services area), thereby providing some certainty about the potential scale of the market for bank sponsors.

- **Phased bank establishment:** Conservation bank guidance from U.S. FWS allows "phased establishment" of banks (U.S. DOI 2003). Bank developers can use this provision if there is uncertainty about demand or sufficient benefit to species in each phase of a project.

- **Combined wetland and species credits**: If a wetland is also habitat for an endangered species and a bank meets requirements for both a wetlands program and a species program, the bank can sell species credits as well as wetland credits (Bean et al. 2008). Although it can sell the credits into two different markets, it cannot sell the same credit/acre twice (U.S. EPA 1995).

- **Reduce competition from different forms of compensation:** Potential competition among different forms of habitat compensation can occur because equivalent standards for all forms of mitigation are not guaranteed in the ESA context. Some programs propose to achieve species benefits with educational or research funds making conservation bank credits a more expensive alternative. The U.S. FWS is attempting to address this issue with new mitigation policy addressing equivalency.

- **Registry**: The RIBITS system set up by the USACE in partnership with the U.S. FWS and NMFS collects data on conservation banks, along with mitigation banks and ILF program projects. Those data include bank location and number and availability of credits (U.S. ACE 2015). RIBITS is not set up as a market exchange, and no market exchanges exist for habitat credits, thus no data on credit demand or prices are collected. The lack of transparency in credit pricing can create a barrier to entry into regional markets.

Effect of Management Mechanisms on Risk and Uncertainty:
Bank sponsors can use phased bank establishment to reduce the scale of upfront costs while they assess potential demand. Clear regulations on equivalency will also help bank sponsors assess the potential for demand. The RIBITS registry may increase transparency on credit supply for potential buyers, but it does not replace the need for a market exchange. It will not help sellers assess demand or potential credit prices.

Like wetland and stream mitigation banks, conservation banks in some districts and states allow mechanisms for the purchase and sale of credits outside of their service area. Although such mechanisms could reduce habitat benefits, they reduce risks for sellers by reducing the risk of insufficient demand and for buyers by increasing the possibility that credits will be available.

Managing Remaining Risk

U.S. FWS guidance on conservation banks includes a variety of mechanisms that may help to reduce risks to buyers and sellers of credits from mitigation banks, but primarily it is focused on reducing the risk that banks fail to protect species and enhance species recovery. Some of the species protection mechanisms impose risks on sellers (bank sponsors), but many of these risks are relieved once credits are approved by the FWS and sold to a buyer. Sellers bear a risk if bank development and credits sales do not go as planned. Buyers who successfully purchase needed credits bear no risk because their liability transfers to the bank. Their only uncertainty is how many credits they will have to buy; the number is based on the

crediting ratios set by the U.S. FWS. While awaiting credits from banks that are under development, buyers will face multiple uncertainties: timing of credit release, final crediting ratios, and credit prices. Buyers and bank sponsors have set up mechanisms outside conservation banking programs to manage these risks.

Vertically Integrated Program

A vertically integrated program would encompass regional or statewide demand and acquire credits to meet it, as is the case with Kentucky's Indiana Bat Fund, which covers mitigation for impacts to all of Kentucky's bat habitat (U.S. FWS 2015d). Some Texas counties have their own HCPs that are authorized to buy bank credits.

Transferring Risk through Contracts

Buyers can set up purchase agreements with banks for guaranteed delivery of a specified number of credits at a specified price. Although this arrangement provides up-front capital to the project developer, it also transfers significant liability to the bank, which must meet its contract agreement even if some of the uncertainties discussed above reduce the credits it generates or the cost at which the credits are profitable. In theory, buyers can sue sellers for fines or penalty costs as well as for undelivered credits (requiring the seller to provide them through generation or purchase) if the seller violates its contract.

Diversified Project Portfolios

Buyers and sellers can also address risks by having diversified portfolios of projects (different species and locations) to hedge risks related to natural variability, scientific uncertainty, regulatory uncertainty, and extreme events. Many of the private businesses involved in species banking are the same organizations that conduct wetland and stream mitigation (e.g., Resource Environmental Solutions and Wildlands). These are diversified businesses designed to manage high up-front costs and risks.

Insurance

In theory, insurance could help reduce risks for banks. Although few insurance products are currently available, Ecosystem Insurance Associates and Lexington Insurance both have insurance products that can function as financial assurance for banks. However, conservation banks do not, at this point, carry insurance.

Programmatic Adjustments

Opportunities for programmatic adjustments to address failures to meet regulatory objectives (in this case, endangered species survival) occur when districts and states update their rules or methods and when national regulatory guidance is reviewed and revised. Adjustments can take into account studies that show, for example, how to better use science (Harding et al. 2001; Watchman, Groom, and Perrine 2001) or realize the economic and ecological benefits of advanced mitigation (Greer and Som 2010).

Carbon Offsets Markets

U.S. programs to limit greenhouse gas emissions from large emitting sectors like electric power, industry, and transportation have looked to the agricultural and forestry sector for low-cost emissions offset opportunities. Some cap-and-trade programs allow trading whereby regulated sectors can achieve specified emissions reductions through the purchase of comparatively low-cost reductions from other regulated sectors and from non-regulated sectors like forestry and agriculture (U.S. EPA 2012). Emissions reductions from non-regulated sectors (those sectors not covered by the emissions cap) are called *offsets*. To ensure that those regulated entities that are buying offsets are staying within their cap (remaining in compliance), the offsets must achieve real, verified, additional, and permanent emissions reductions (CARB 2012). One of the reasons agriculture and forestry are often outside a cap is that they are difficult sectors to track and measure because of the large number and variety of landowners and relatively low levels of emissions distributed over large landscapes. As a result, agriculture- and forestry-based offsets programs tend to have detailed and strict quantification protocols requiring third-party verification.

There are two types of carbon offsets projects: those that reduce emissions and those that sequester them. Offsets that reduce emissions include those that use nitrification inhibitors to reduce nitrous oxide emissions from agriculture, that manage water on rice paddies to reduce methane emissions, and that avoid conversion of forests to other land uses to reduce losses of stored carbon. Offsets that sequester and store carbon include those that restore forests or wetlands, improve forest management, and maintain organic matter (no-till practices) on agricultural and rangelands.

There are two types of carbon offset markets: voluntary and regulatory. In the first type, voluntary markets, credits are primarily purchased by companies, institutions, and individuals working to achieve sustainability targets or goals. These markets often have new and emerging types of offsets credits that may at some point enter the regulatory market. The second type, regulatory markets, are driven by state or regional laws and are the focus of this report.

In the United States, two regulatory cap-and-trade programs are active: the Regional Greenhouse Gas Initiative (RGGI) in the northeast, and the California program.[22] RGGI is a seven-state (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont) cooperative effort to cap emissions from the power sector. It allows five types of offsets projects, including carbon sequestration through U.S. forest projects (reforestation, improved forest management, avoided conversion, and afforestation) and avoided methane emissions from agricultural manure management operations. Low allowance prices in the RGGI program have kept offsets from developing as an active part of the program.

This discussion uses examples from the California Compliance Offset Program, which was developed in response to the California Global Warming Solutions Act of 2006 (AB32), which aims to reduce statewide emissions to 1990 levels by 2020. The cap-and-trade part of this program will cover up to 80% of the state's emissions. The program, which is regulated by California's Air Resources Board (ARB),

[22] In California, offsets are also now being used to help offset emissions from various state-regulated development activities. The California Air Pollution Control Officers Association (CAPCOA) developed the Greenhouse Gas Reduction Exchange (GHGRX) to provide information on greenhouse gas (GHG) credits available within participating air districts. Credits on the exchange can be purchased to mitigate GHG emissions under the California Environmental Quality Act (CAPCOA 2014).

defines an offset as "a tradable compliance instrument issued by ARB that represents a GHG [greenhouse gas] reduction or GHG removal enhancement of one metric ton of CO_2e ($MTCO_2e$). The GHG reduction or GHG removal enhancement must be real, additional, quantifiable, permanent, verifiable, and enforceable" (CARB 2012). Allowable offsets from the agricultural and forestry sector include

- Livestock projects that capture and destroy methane released by livestock manure (this methane in some cases is used to generate electricity (43,183 compliance and 597,458 early-action credits issued);

- Urban forest projects that plant trees in municipalities, school campuses, and other urban environments to sequester emissions (no credits issued); and

- U.S. forest projects that reforest areas, improve forest management, or avoid the loss of forests (3,378,928 compliance and 2,681,524 early-action credits issued) (CARB 2014c).

In June 2015, ARB approved rice cultivation projects that alter water management to reduce emissions of methane (CARB 2015a).

Exploration continues for other offset activities—both emissions reducing and sequestration enhancing—that are not yet incorporated into regulatory programs but that are being developed for voluntary markets—activities such as agricultural nitrogen management to reduce nitrous oxide emissions (CARB 2013) and use of compost to enhance carbon sequestration in rangelands (ACR 2014).

Three voluntary registries are registering domestic credits for both the voluntary and regulatory-driven markets: the Climate Action Reserve (CAR), the Verified Carbon Service (VCS), and the American Carbon Registry (ACR).

Who Is at Risk and What Risks Do They Face?

In wetland and species mitigation and conservation banking, liability transfers from the regulated permittee to the banks. But in the California offsets program, liability and responsibility remain with the regulated entity. Regulated entities will be held responsible for achieving their required emissions reductions through direct emissions reductions and any offset credits acquired through trading. They will be held liable if offset credits are invalidated and reduction requirements are not met.[23] Firms holding an invalidated credit must replace it to remain in compliance. If failure to have sufficient credits is due to project failure or offset project developer error, there are ways for legal liability to be shared or passed to the seller. Offsets programs are designed to reduce these risks to the buyers. The offset protocols approved by the California Air Resources Board (CARB) contain some of the strictest requirements of any in the current carbon market (Morris and Fell 2012). It is common for the buyer's legal liability to be

[23] Not all programs operate this way. To address the issue of permanence in conservation projects, the Alberta offset system has developed an "assurance factor approach." Assurance factors are used to discount the offset credits generated from carbon sequestration projects in any one year to the volume of offset credits that would be considered permanently sequestered. Once discounted, the liability is transferred from the project proponent to the government of Alberta, and the offsets achieved are valued as permanent (SEI 2011).

shared with project developers in purchase agreements, and some of a developer's liability can also be passed on to landowners in purchase agreements.

For regulated carbon offset buyers, there are two overarching types of risk: performance risk, or the risk that purchased offset credits fail to produce expected reductions, and market risk, or the risk that insufficient numbers of credits or allowances at expected prices are available.

For carbon offset developers (sellers), risks will vary over the cycle of project development. Certain risks arise before a project gets accredited (verified and registered), such as failure to meet program standards or changes in program requirements. The failure of projects to produce expected offset credits may mean having insufficient credits to meet contracted agreements. Other risks occur after projects are registered but before the sale of credits, like insufficient buyer demand, credit prices that are lower than implementation costs, monitoring failures that keep reductions from being tracked, and project-damaging extreme events. And finally, after credits are sold, contracts can leave some liability for behavioral uncertainty with the seller or landowner. The duration of the risk of invalidation is limited to eight years from credit issuance, unless the credit undergoes a second verification, which is rare, reducing the invalidation time frame to three years.

Landowners whose lands are under permanent restrictions or long-term (100-year) contracts that are associated with forest-management-based offsets can face opportunity cost risks, if profits for carbon offsets do not provide revenue sufficient to offset or exceed other uses of the land.

The public or the program bears two risks. The first is that the offsets are not real and thus expected reductions in greenhouse gases will be lower than expected and paid for. The second is that the offset program does not contain costs because it can't provide a sufficient number of low-cost credits to help reduce the regulatory cost of the cap-and-trade program, increasing costs of the program to the California economy.

Five Types of Uncertainty and How They Can Be Managed

The two types of carbon offsets projects—those that reduce emissions and those that sequester carbon—each have different types of risk that are shaped by various uncertainties. The California Compliance Offset Program has mechanisms to manage many of these uncertainties.

Technical Uncertainty

Natural Lag Time

Avoided emissions projects tend not to have significant time lags because the avoided releases are credited as annual releases. By contrast, carbon sequestration projects can involve significant time lags because it can take years for a sufficient amount of carbon to accumulate in, say, an afforested or reforested area and thereby provide offset credits.

Management Strategy:

Offset projects cannot release credits for sale until greenhouse gas emissions are already avoided or the carbon is already sequestered and verified. As a result, time lag is not a risk for buyers of credits, but it can be a risk for sellers (project developers).

Natural Variability

Natural variability can increase or reduce the number of credits a project will receive relative to predictions, so it can be a risk or a boon to project developers. Because offsets programs use pay-for-performance approaches, natural variability may affect the number of credits generated, presenting risk only for the seller, not the buyer.

Management Strategy:

Offset projects are verified before they can release credits. Periodic measurement and verification, which is required for all project types, can be used to adjust estimates to reflect a project's actual emissions reductions. Livestock projects are a bit different in that their credits are based on real-time monitoring rather than on estimates of these reductions. Monitoring equipment is required to measure methane reductions within 5% of actual emissions reductions. If data are missing, a data-substitution protocol is used for crediting. During any period that equipment is inoperable, no emissions reductions can be credited (CARB 2014b).

Scientific Uncertainty

Carbon sequestered in trees and emissions captured from livestock manure and burned are relatively easily measured with well-established methods (CARB 2013). Compared with other types of GHG emissions reductions projects, these types of greenhouse gas reduction projects have predictable time lags and tractable variability and measurement uncertainty and therefore were the first offset projects allowed in the California Compliance Offset Program. Nevertheless, they and all other carbon offset projects are subject to three types of uncertainty related to quantification of emissions reductions: additionality, permanence, and leakage.

Additionality raises the question whether or how much of the reductions would have occurred without the project. There is uncertainty in selecting a baseline (what would have happened without the project) against which emissions reductions or sequestration should be measured (Trexler et al. 2006). For forest offset projects, the baseline would be estimated on the basis of standard models for forest growth by region and forest type (e.g. Van Deusen and Heath 2015; USDA 2015). For agricultural offset projects, there are models to estimate baseline carbon storage or methane emissions (e.g., USDA, CSU, and NRCS 2015), but these models may have greater uncertainty than the forest models because calibration and validation data for agricultural activities are less robust than those for forest activities, particularly in some geographic regions and for some production systems. Although uncertainty about the counter-factual—what would have happened without the project—can be reduced, it cannot be eliminated. Additionality is a concern for all types of carbon offset projects.

Permanence refers to the requirement that sequestered carbon be stored long term, usually 100 years (CARB 2011), to offset the regulated entity's allowed release of greenhouse gases. Natural disturbances (pests, wind) and variability (dry year, wet year) as well as management activities (clearing of understory to reduce fire risk) can result in periodic carbon losses from a forest or agricultural field. If significant, these losses need to be accounted for in the annual release/sale of credits. These periodic losses from forests can be modeled or measured fairly well, but the science and thus the models for carbon losses from agricultural systems are less robust, and measurement would be expensive (Olander et al. 2011). Permanence is only an issue for carbon sequestration projects.

Leakage refers to the risk that emissions reductions in one place will result in a shifting of activities and their emissions to another place. Because leakage is a market-induced phenomenon, it is only an issue for projects that can result in the reduced production of a commodity (e.g., timber, agriculture). It is not an issue for avoided livestock manure emissions if it has no impact on livestock products. Leakage risk has to be estimated because it cannot be directly measured. Estimates can be based on elasticity in product demand (Murray, McCarl, and Lee 2004).

Management Strategy:

Robust predictive models: The USDA and other organizations have made and are continuing to make significant investments in robust predictive models and measurement approaches that can reduce uncertainties and capture variability and time lags.

Detailed and conservative project protocols: Risks can also be managed through development of robust project protocols. The protocols used by ARB are conservative to handle scientific uncertainty and natural variability and lags as well as uncertainties raised by additionality, permanence, and leakage (Table 4.1). In the context of offsets, ARB defines *conservative* as "utilizing project baseline assumptions, emission factors, and methodologies that are more likely than not to understate net GHG reductions or GHG removal enhancements for an offset project to address uncertainties affecting the calculation or measurement of GHG reductions or GHG removal enhancements" (CARB 2012).

Table 4. California's offset protocols use carefully selected measurement methods to manage scientific uncertainty

Protocols	Measurement that manages for uncertainty
Livestock protocol (CARB 2014b)	For estimating project emissions relative to a baseline, the protocol calls for use of both an estimation model and meter readings under standard conditions and for reporting of the lessor of the two resulting measures. The estimation model is based on site-specific data such as type and number of animals, local temperature, and type of manure management system.
Urban forest protocol (CARB 2011)	The protocol requires use of field inventory data for both the baseline and project estimation. It requires a confidence deduction if the sampling error is greater than 5%. This deduction increases as error increases up to 20%, beyond which the project would receive no credit. To track variability and permanence, the protocol requires project measurement to be repeated every 10 years.
U.S. forests protocol (CARB 2014c)	For both baseline and project estimation, the protocol requires accepted field inventories and modeling of required carbon pools. For individual project estimations, a confidence deduction is required if the sampling error (at 90% confidence interval) is greater than 5%. This deduction increases as error increases up to 20%, beyond which the project would receive no credit. To track variability and permanence, the protocol requires annually reported project estimates and field inventories of major carbon pools every six years. Leakage risk is calculated as a secondary emission and is subtracted from total reductions. In addition, to manage for leakage within ownership, forest owners must demonstrate that all their forest holdings, not just in the project area, are enrolled in the Forest Stewardship Council, the Sustainable Forestry Initiative, or the Tree Farm System.
Rice cultivation protocol (CARB 2014d, 2014f)	The protocol uses an adapted ARB-approved version of the DeNitrification-DeComposition (DNDC) model, which requires calibration to the site, equilibration with 20 years of data from the baseline period, and site-specific data on soil, climate, and cropping practices to model both the baseline and changes in emissions. The model estimates not only changes in methane but also any concurrent changes in nitrous oxide emissions and soil carbon to adjust for changes in net greenhouse gases. The protocol requires a variety of deductions for uncertainty based on how well the model is calibrated to a given region and for uncertainty about input data.

Effect of Management Mechanisms on Risk and Uncertainty:

A pay-for-performance requirement reduces risk for buyers but can place a burden on sellers (project developers) of carbon sequestration projects, which tend to accumulate carbon slowly and thus will only have small numbers of credits to sell in their early years and at the risk of losing future credits if a reversal or loss of stored carbon occurs. Moreover, the requirements for periodic project monitoring and verification can be costly for sellers (project developers). In the compliance market, as compared with the voluntary market, there are many fewer afforestation and forest management projects than avoided emissions projects (ACR 2015; CARB 2014a). The limited supply of carbon sequestration projects could lead to a risk of insufficient supply of offsets for buyers.

The detailed and rigorous protocols used by CARB greatly reduce performance risks for buyers and for the California Compliance Offset Program. They also provide a way for sellers to predict their future carbon credits; however, their application can be expensive, resulting in high transactions costs for sellers. In the case of forests carbon offsets, the California protocol's approach for scientific uncertainty can be managed by the seller. Because sampling error determines credit (confidence) deductions, sellers can decide whether it is worth the cost of additional sampling to reduce their error or whether they'd rather take the deduction.

Extreme Events

Extreme events like fire, pest outbreaks, and wind storms can damage or destroy the functionality of multiple offsets projects in a region simultaneously. These events would be classified as unintentional reversals, not in the control of the project developer. Intentional reversals are discussed in the next section.

Management Strategy:

- **Resilient design**: Protocols could require offset projects to include design elements that increase the projects' resistance or resilience to common extreme events (e.g., require fuel load management in forests). Under the California Compliance Offset Program, forest offset projects can use such design elements to reduce their reversal risk rating, which determines how much they have to contribute to the Forest Buffer Account (CARB 2014c).

- **Pay for performance:** Projects that avoid emissions, like methane from livestock or from rice fields, have no stored carbon at risk of release (or reversal). For these projects, the worst-case scenario is that they may have no credits to sell while recovering from an extreme event.

- **Verification:** Required verification for both avoided-emissions and sequestered-carbon projects will help to track the effects of extreme events on the projects. California requires sequestration projects to verify that stored carbon is still in place every six years and to annually address disturbances and resulting reversals (CARB 2011, 2014c).[24]

- **Contract length:** Sequestration projects have a minimum contract length whereby they commit to keep carbon in place for 100 years (CARB 2012).

- **Program buffer:** California's Compliance Offset Program includes a required risk-sharing mechanism that may help buyers address some of the risks inherent in extreme events. Whenever it issues compliance credits, the ARB requires that forest projects place a percentage of them in the Forest Buffer Account. The amount of contribution is based on a project-specific risk evaluation (CARB 2011). The buffer pool will cover losses from unintentional reversals (e.g., events caused by natural disturbance) by retiring the number of affected credits. (Intentional reversals are discussed in the section on behavioral uncertainty.)

[24] Because credits are issued and sold at the time of carbon sink creation, sequestration projects are being paid in advance of serving their full offsetting function, the duration of which California sets at 100 years.

- **Banking**: Regulated entities in the California market can save allowances for future use (AB32). These banked allowances could be used to fill gaps caused by reversal-invalidated offsets. They can also provide some protection against a short-term drop in offset credits for avoided emissions after a disturbance that takes digesters or other management equipment off line.

Effect of Management Mechanisms on Risk and Uncertainty:
Many of the risk management mechanisms incorporated into the California Compliance Offset Program to address losses of stored carbon are designed to ensure that the program meets its objectives. In the context of extreme events, regulated buyers, who bear liability for project failures, can use the programmatic buffer to reduce or eliminate the risk of unintentional reversals on purchased credits, but sellers (project developers) cannot receive relief from the buffer for unsold credits. Thus carbon sequestration projects hold more extreme-event risk for sellers than for buyers.

The long contract period and replacement requirements for forestry and other carbon sequestration projects result in long-term risk for regulated buyers. Some of that risk might be shared with project developers through contracts, and some is shared with the California Compliance Offset Program through the unintentional release buffer. The buffer can provide a significant reduction in risks associated with extreme events for buyers.[25]

Most risk management mechanisms such as verification, buffer set asides, long-term contracts, or permanent easements on land place an additional burden and risk on project developers. Risks can be passed on to buyers once credits are sold, but upfront costs can pose a risk. Damage to projects that have not yet fully sold credits can result in a loss of credit income and involve equipment and infrastructure repair and replacement costs.

Behavioral Uncertainty

Carbon offset projects can fail or produce reduced benefits due to human error or mismanagement or a necessary adjustment in management. For example, a project developer or its contractor may not properly install digester equipment, make mistakes in the quality control schedule for meters, fail to maintain required forestry practices, or need to thin a stand to manage for fire risk.

Management Strategy:

- **Periodic verification and reporting requirements**: The California Compliance Offset Program, like all active carbon offset programs, requires approved third-party verification of new projects before credits can be sold (Table 1).[26] Protocols also require annual reporting. Verification and

[25] In the California market, ultimate responsibility is borne by credit buyers, but this responsibility will often be passed back through purchase agreements (contracts) to the aggregator/project developer and sometimes in part to the seller/landowner through a shared liability agreement.

[26] Although the existence of a growing and healthy forest can be verified with a quick visual inspection, certain behavioral practices, like changing water management in rice paddies or reduced fertilizer use on a farm, cannot. If verification of behavioral practices becomes cost prohibitive, programs could instead estimate the risks of mismanagement and incorporate them into how they credit projects (e.g., by requiring a slightly higher trading ratio to cover the approximated risk). A similar process has been used for carbon offset credits for reduced tillage farming in Canada (Alberta Environment and Water 2012).

credit sales are typically on an annual basis, although verification of forestry projects can occur every six years. Ups and downs in emissions reductions can be incorporated as annual variation in reported reductions, which will then result in an automatic alignment in crediting when the project account is quantified and verified. Thus intentional reversals can be trued up during operations if sufficient carbon is sequestered to replace lost carbon.

- **Permanent protection:** Like wetland and stream mitigation and conservation banks, carbon sequestration projects (but not emissions reduction projects) require permanent protection of sites through conservation easements with permanent land use restrictions. The required long-term (100-year) contract goes hand in hand with the projects' expected long-term (100-year) carbon storage (Table 1).

- **Long-term management plan and forest certification:** Forest carbon sequestration projects in California require renewable long-term management plans and formal certification to ensure good stewardship of managed forests (Table 1).

Contract length: Projects with stored carbon require a minimum contract length whereby a project commits to keep the carbon in place for 100 years from the date the last credit is issued (CARB 2012).

Table 5. Mechanisms California's offset protocols use to manage behavioral uncertainty

Protocols	Managing for behavioral uncertainty
Livestock protocol (CARB 2014b)	The protocol requires hourly reporting of management activity for all monitoring devices as well as site verification at least every 24 months. All gas-flow meters and continuous methane analyzers are required to be cleaned and inspected on a quarterly basis and field checked by a trained professional. Even if operating within specifications, equipment must be calibrated by the manufacturer at least every five years.
Urban forest protocol (CARB 2011)	The protocol requires a site visit and inventory for initiation of projects, annual reporting, and a third-party verification review of records every six years.
U.S. forests protocol (CARB 2014c)	The protocol requires multiple prevention measures, including certification by the Forest Stewardship Council, the Sustainable Forestry Initiative, or the Tree Farm System; adherence to a renewable, long-term (50-year-minimum) management plan that demonstrates sustainable harvest levels and that is sanctioned by a state or federal agency; and a deeded conservation easement that ensures growth equals or exceeds harvests over time. Annual monitoring reports that incorporate annual inventory data, sample growth plot data, and responses to any disturbances must be submitted. Also required is verification through a site visit at least every six years that includes a review of annual records. Operator calculations of carbon have to be within 10% of the verifier calculations.

Effect of Management Mechanisms on Risk and Uncertainty:
Verification and reporting for avoided annual emissions projects, like methane management livestock and rice cultivation, help buyers ensure that credits are real and that they present minimal risk to sellers. Costs for verification can also be passed on to buyers.

In contrast, the permanent easements, 50-year management plans, and certification requirements for forest carbon storage (avoided conversion) sequestration (forest management) projects can place significant risk on sellers. Moreover, if the carbon market does not provide the expected revenue, restrictions on landowners' future development and use rights can prove a significant opportunity cost. If a developer wants to back out of a reforestation or avoided conversion carbon commitment, he or she must return compliance credits equal to the total number of ARB-issued offset credits. In the case of forest management projects, the number of credits that projects are required to return is determined by the number of years that have elapsed since the projects began (CARB 2014c).

Illegal activities result in a violation of a project's regulatory compliance, presenting a risk to both sellers and buyers. No credits can be issued for the reporting period in which the violation took place. In the case of forestry projects, a violation could be due to illegal marijuana growing operations by entities unbeknownst to the project developer. In the case of livestock projects, violations could be related to water quality.

Regulatory Uncertainty

Regulatory uncertainty is significant for voluntary programs because buyers and sellers often are trying to buy into pre-compliance markets with the hope that these markets will eventually be incorporated into regulatory markets. Once regulations provide clarity on rules and protocols (especially at the level of detail found in the California Compliance Offset Program), this uncertainty and the risk it imposes drop substantially. At present, litigation on rules and protocols also pose uncertainty—the rules and protocols may change as a result. There is also a possibility that state or federal agencies will at some point regulate some of the activities that are now incentivized by offset programs. If so, credits for these activities will no longer be issued.

Management Strategy:

- **Set regulations**: Regulations are relatively certain and are not expected to change much in the near future in California.

- **Standard operating procedures**: Very specific and detailed operating procedures, regulations, and rules as well as project protocols provide clarity for sellers and buyers.

- **Guaranteed project life:** If rules change and credits will no longer be issued for certain types of projects, regulators can guarantee credits for existing (but not new) projects for a period sufficient for projects to break even on costs.

Effect of Management Mechanisms on Risks and Liability:
The California Compliance Offset Program provides clear regulatory structures and rules to guide the offset market. Thus buyers have certainty about their need for credits, and from market operations to date, they have some understanding of the potential supply and cost of credits. At the same time, sellers have clear protocols to follow so they can estimate the number of credits they will receive, and they have confidence that they will have valid credits once their projects are complete. Sellers also have confidence that the state's policies will remain in place and drive demand for their credits.

Reforestation and forest management projects can take a while to become established. Sellers will need certainty that demand for credits and sufficient prices for credits will remain in place long enough for them to break even or profit on these projects. They also need some certainty that the rules and credits they receive will not change. This certainty can be ensured by allowing projects to receive credits for a guaranteed period of time on the basis of the rules that were in place when the projects were first issued credits, even if the rules are updated and credit values for an activity are reduced. According to CARB, as long as a project is listed prior to the date that a new version of regulation is "effective" (typically three months after board adoption), the old regulation will apply for the life of the project.

Regulatory uncertainty is a challenge faced primarily by pre-compliance or voluntary offset markets. Transparency about which project standards or best practices are likely to meet regulatory standards can help advance pre-compliance voluntary standards. Certainty about meeting regulatory standards will increase the incentive for project developers to begin creating projects and generating supply. In California, a process has been developed to bring in early-actor credits for approved project types developed under voluntary standards (CARB 2014e).

Market Uncertainty

Regulatory uncertainty can lead to uncertainty in supply and demand, causing market uncertainty. This market uncertainty is a significant factor for voluntary markets, but less so for California's regulatory program. In the California Compliance Offset Program, the demand side (uncertainty for sellers) is relatively predictable in the short term given the regulatory cap set by California and the emissions projections from the capped sectors. In the longer term, shifts in technology like the recent growth of natural gas due to new drilling techniques or the potential for cheaper renewables or other technological advancements can cause a significant shift in demand. On the supply side (uncertainty for buyers), the introduction of new types of offsets into the market can have a large impact if the offset type has a potentially large supply of credits or low cost. Because a new offset protocol takes years to be developed and approved, the regulatory market will see these new types of offsets coming.

Management Strategy:

- **Demand projections**: Under a regulatory program like California's, it is possible to project likely demand for offsets over time by considering energy demand, transportation use and advancements, and changes in the regulatory cap (which will lower over time). Stevenson, Morris, Martin, and Grady (2012) were able to predict a significant shortage of compliance offsets if no additional protocols were adopted. Two new protocols—for mine methane capture and rice cultivation—may help address this deficit.

- **Controlling offsets project types**: In regulatory markets, regulators control the types of offsets allowed and specify which types of projects are allowable. Thus they can play a role in managing the potential supply of offsets, allowing new project types that will provide additional supply if there are offset shortages (Stevenson, Morris, Martin, and Grady 2012). Recently, as noted above, California has developed and approved a mine methane capture protocol and a rice methane management protocol (CARB 2015a). To ensure sufficient offset supply, protocols must allow projects to have the potential for profitability, which means making sure transactions costs and regulatory burdens required in protocols don't hamper development of projects. Because application of California's urban forest protocol has not proven cost effective, urban forest projects have not been developing (McPherson 2008).

- **Registry**: Registries support confidence in the market by, for example, ensuring that credits are not being sold twice. The California Compliance Offset Program uses detailed public registries held by its approved registries: the Climate Action Reserve, the American Carbon Registry, and the Verified Carbon Standard. These interconnected registries provide information on projects (name, type, operator, and location) and issued credits (CARB 2015b). Underlying these registries is the Compliance Instrument Tracking System Service (CITSS), a confidential management and tracking system for both offsets and allowances developed for the Western Climate Initiative cap-and-trade programs (WCI 2015; CARB 2015d).

- **Exchange:** Registries do not provide an easy way for the public to track sold credits and available supply. However, the trading platform Carbon Trade Exchange (CTX) and the Climate Policy Institute provide current market prices for all credit types.

Effect of Management Mechanisms on Risks and Liability:
The stability of the regulatory structure and the track record of a functioning offset program help reduce uncertainty in the California market. The largest remaining driver of uncertainty in the market would be an economic downturn or technology breakthrough that significantly and rapidly dropped regulatory demand for GHG reductions and thus carbon offsets. Mechanisms to reduce market fluctuation risks are built into most cap-and-trade policies, and the California system is no exception. It contains a range of cost-containment mechanisms, including but not limited to allowance banking, an auction floor price, and administrative allocation of allowances (CARB 2013). All of these mechanisms will help manage fluctuations in the market price for both allowances and offsets.

Another market uncertainty for offsets that could create a risk for sellers would be the approval of a new offset type that is abundant and low cost. Although reduced emissions from deforestation and degradation (REDD) credits could flood offset markets, they are unlikely to do so in California. Jurisdictional REDD+ credits are under consideration for future approval in the California Compliance Offset Program, but unless current demand ramps up (with higher prices for carbon), it appears unlikely that REDD credits will be allowed. If they are, they could become a significant part of the market (Lueders et al. 2014).

Transparency and tracking of carbon offset projects and allowance prices provide significant market information and lower risks for both buyers and sellers.

Managing Remaining Risk

Many potential risks for buyers and sellers are well managed through the carbon offset program design in California. However, some risks remain, and more risks persist for voluntary markets. Buyers and sellers (project developers) have mechanisms outside the California Compliance Offset Program that help to manage these risks.

Transferring Risk Through Contracts

Buyers can set up purchase agreements with brokers or project developers for guaranteed delivery of a specified number of credits at a specified price. Although these agreements provide upfront capital to project developers, they also transfer significant liability to sellers, who need to meet their contractual obligations even if some of the uncertainties discussed above reduce the credits they generate or the cost at which the credits are profitable. Buyers can sue sellers for fines or penalty costs as well as for the undelivered credits (requiring the seller to provide the credits through generation or purchase) if sellers violate their contract. Buyers can also require collateral against offset invalidation, which one buyer, Pacific Gas and Electric, has indicated it may do (Morris and Fell 2012).

Vertically Integrated Program

Vertically integrated programs involve one organization overseeing both the demand and supply of credits. Large emitters could establish their own internal offset project development and aggregation business but are not currently doing so.

Private Buffers

As is the case in other markets, sellers (project developers and brokers) can use extra buffers on their own projects to manage all sorts of risks. Buyers can also hold their own internal buffers by buying extra offset credits. In California, buyers can bank allowances—that is, purchase extra GHG reductions from a regulated entity and use them as a buffer against possible risks (CARB 2015c). Buyers can also buy from the better-hedged brokers to reduce their risks.

Diversified Project Portfolios

To hedge risks related to natural variability, behavioral uncertainty, and extreme events, buyers and sellers can diversify project portfolios with regard to project type and location.

Insurance (Transferring Risk to Third Parties)

In theory, insurance can help sellers address risks to projects before project reductions are verified and credits are received as well as help project developers with the risk of extreme events. Private insurance for offsets projects is an emerging product. Project developers could insure traditional infrastructure or property that is part of a project—for example, the value of timber in a forest management project—but they cannot insure the value of the carbon offset associated with the forest (Lowrimore 2012). It remains uncertain whether publically supported insurance (purchase guarantees or credits pools) could fill the insurance gap and help support the development of new offsets projects. Losses stemming from poor management (behavioral uncertainty) are likely uninsurable and will likely be dealt with in contract terms. On the other hand, insurance products have been developed to protect buyers from invalidation of carbon offset credits sold as part of California's cap-and-trade program (Gonzalez 2013; Doan 2013).

Programmatic Adjustments

Programmatic adjustment of the California Compliance Offset Program is mostly likely to take the form of changes to the amount or types of allowable offsets. Such an adjustment might be made due to perceived risks, new science that undermines an offset type, or market demands, but it will not be due to direct measures of program outcomes. No measures are sufficiently accurate to ensure that the reduction in the GHG footprint resulting from offsets in California is equal to the state's emissions cap.[27]

[27] The GHG signal from an offsets program of the scale of California's program will be much smaller than background carbon emissions fluxes and the changes in those fluxes generated by other climate policies. Consequently, a significant signal-to-noise problem is created for any direct regional measure of emissions changes resulting from the offsets program.

Water Quality Trading

Water quality trading in the United States is developing as a way to achieve environmental goals while realizing efficiencies in meeting regulatory requirements and accommodating new growth. Point source discharges of effluent (polluted water) are regulated under section 402 of the Clean Water Act (CWA). The regulated discharges can include nutrients, sediments, other pollutants, or temperature. The CWA imposes load restrictions, called total maximum daily loads (TMDL), on water bodies that are determined to be impaired.[28] Point source dischargers are required to meet effluent limitations specified in National Pollutant Discharge Elimination System (NPDES) permits. When those sources are in an impaired watershed with a TMDL, the objective is to have sufficient reductions across sources to stay below the TMDL. Regulated sources can meet these load reductions by making changes to their point source (treatment facility or confined feeding operation), and if a trading system is in place, the sources may be able to purchase reductions from other point sources or non-point sources.[29]

These permits can be developed separately for each facility in an impaired watershed or can be developed to cover a group of or all facilities within a watershed (Clean Water Act of 1972). Water quality trading is being used to increase flexibility for regulated point sources by allowing trading of pollutant load reductions among these sources and often also with unregulated point sources (U.S. EPA 2003, 2004, 2007a).

Historically, NPDES permits have been classified into two categories: individual (applying to only one facility) and general (applying to multiple parts of one facility or many similar facilities). Since 2003, the EPA has advocated for the use of watershed-based NPDES permitting, especially where water quality trading is being developed. Watershed-based permits combine elements of both individual and general permits while reflecting consideration of watershed goals and the impact of multiple pollutants, including those from non-point sources (U.S. EPA 2007b).

Watershed permits that include multiple point sources allow those sources to vary discharges across the permitted watershed as long as the aggregate limitation at the downstream compliance point is not exceeded (U.S. EPA 2007b). Watershed-level permits can facilitate trading, given that the outcomes of point source and nonpoint source reductions are measured together at a downstream compliance point. Only the point sources are held accountable for compliance. If all the sources under a permit have a single owner, the permittee is responsible (retains liability) for meeting the aggregate effluent limitation of its sources and trades (where they are included in the permit and allowed). When multiple owners—co-permittees—share a downstream compliance point, the individual discharges of each permittee are still monitored in the event that the downstream compliance point limitation is exceeded. When this occurs, each individual permittee is audited, and only those permittees in non-compliance with individual effluent limitations are held liable (MDE 2008). If no one entity is out of compliance, a revision of the NPDES permit limits may be triggered.

[28] If a water body does not meet the water quality standards required under Section 301 of the CWA, it is added to the 303(d) list of impaired waters. Clean Water Act of 1972, 33 U.S.C. § 1251 et seq. (2002); http://epw.senate.gov/water.pdf.

[29] A point source is typically the end of a pipe or a drainage ditch with concentrated effluent, whereas a non-point source is a more diffuse source like agricultural fertilization.

When trading occurs under regulatory permits (NPDES), the permit holder (regulated entity) will be held responsible for achieving permit-specified effluent reductions; credits acquired through trading will be counted toward those reductions.[30] If the reductions are not achieved, whether at the point of measurement or because of a failure of a credit-producing activity (e.g., a failed best management practice), regulatory liability falls to the regulated entity or entities, the permit holder(s) (U.S. EPA 2003). If the regulated entity does not meet compliance due to a project failure associated with purchased credits (point or non-point), it will have to replace the credits during an appropriate reconciliation period (U.S. EPA 2003, 2007a). If the credit was purchased through a broker, the broker may address project failures by providing other credits held in its portfolio of projects or by providing credits from its own risk buffer if it has one.[31] If, however, the aggregator fails to live up to its contract to provide purchased credits, the regulated buyer could hold the aggregator liable for breach of contract and any associated costs (Showalter and Spigener 2007; Ullo 2007).

If TMDL standards are not met, compliance requirements at a programmatic level may be re-negotiated, effectively halting trading until new effluent limitations are in place (U.S. EPA 2015). In the TMDL context, there are four types of water quality market offsets: (1) offsets to comply with existing permit conditions, (2) offsets to service new or expanded wastewater discharges under the NPDES permitting regime, (3) offsets serving localities/municipalities under their MS-4 permit for separate storm sewer point sources with TMDL-driven reductions, and (4) offsets for stormwater from construction and industrial site permittees that need offsets for new development (U.S. EPA 2007a).

Ongoing pollutant releases, like wastewater releases from treatment facilities, or heated water from energy facilities, which may vary over time, are accounted for annually. These ongoing releases can be addressed through a range of activities, some resulting in annual reductions in pollutant loads like fertilizer reductions on a farm, and others in more permanent reductions or long-term storage like the creation of a buffer strip that may be credited annually for its contribution. Permanent impacts, like land conversion, are increasingly required to find a permanent offset to replace the lost stormwater retention and nutrient benefits.

Who Is at Risk and What Risks Do They Face?

In water quality trading, the regulatory risk is placed on the regulated buyer by law. For the regulated buyer, there are two types of overarching risk: (1) the risk that purchased credits fail to produce expected reductions and (2) the risk that insufficient numbers of credits at expected prices are produced after a strategy of using water quality credits, rather than infrastructure, has been pursued to meet new NPDES limits. There can be a financial risk associated with the use of credits in terms of possible penalties for not

[30] Effluent limitations on point sources are enforced through self-monitoring and reporting of effluent data. State and federal environmental programs enforce compliance through routine audits of a point source's effluent data (U.S. EPA 2007a, 2009). These audits are conducted by taking samples at a specific location set forth in the permit (U.S. EPA 2010). This point could be the end of the pipe at one plant (individual permit) or at a designated location in a water body shared by point sources (general or watershed-based permits). If a regulated entity chooses to meet pollutant discharge standards by purchasing water quality credits, the transaction must be recorded in some form in the permit (U.S. EPA 2007a, 2009). Permits will generally state the effluent limits that will be measured at a designated point in the watershed and will provide details about what can be met through trading. Regulated entities have to keep records of certified and verified credits that they have purchased to show they have met their permit requirements.

[31] Extra credits set aside (usually a percentage) with each sale of credits to provide a hedge against project failures.

meeting permit requirements. Some of the financial risk associated with a failure to produce credits that meet requirements could be shifted to brokers or sellers in purchase contracts.

Risks faced by the seller will vary over the cycle of project development. Before projects are accredited (certified, verified), sellers' risks include failure to meet program standards or changes in program requirements. Before the sale of credits but after accreditation, risks include insufficient buyer demand, credit prices lower than implementation costs, or project damage due to extreme events before credits are sold. When credits are on an annual cycle (credited every year for that year's reductions), seller liability ends after they are sold. However, if credits are sold for a longer contract period like 10 years, or if they are permanent offset credits, risks of project failure or underperformance will need to be addressed or tracked. In programs that offer permanent offset credits, like North Carolina's buffer program under the Division of Mitigation Services, these risks become programmatic risks with a potential impact on achieving environmental goals.[32] For other programs, liability for project failures is ultimately likely to fall on the seller or broker through sale contracts that transfer financial liability from the buyer.

Landowners whose lands are under permanent restrictions or long-term contracts could face opportunity cost risks if profits for water quality credits do not provide revenue sufficient to offset or exceed revenue potential from other uses of the land.

The public or program bears a couple of risks. First, the water quality benefits from non-point source projects may not be as great as expected (technical risk), and thus overall water quality benefits will be lower than expected. Second, non-point sources may not provide a sufficient number of low-cost credits to help reduce the regulatory cost of the water quality program.

Five Types of Uncertainty and How They Can Be Managed

Five types of uncertainty raise risks for buyers and sellers in water quality trading markets (Walker and Selman 2014; Willamette Partnership, WRI, and the National Network on Water Quality Trading 2015). Management of these risks is described below.

Technical Risk

Natural Lag Time

A time lag between when a best management practice is installed and verified and when it actually achieves predicted pollutant load reductions could delay reductions in the water body of interest. Such time lags can be particularly long for BMPs such as planted riparian forests or wetlands (Szpir et al. 2005; Line and Jennings 2002).

Natural Variability

Effectiveness of BMPs will vary, depending on factors such as location, weather, soils, and topography. For example, cover crops, which help control soil erosion and can fix nitrogen, are best suited to humid and subhumid regions where they will not reduce the water supply for next year's crop (USDA and

[32] The division was until recently called the Ecosystem Enhancement Program; see http://portal.ncdenr.org/web/eep.

NRCS 2015). And grassed swales, which may reduce nutrient export from agricultural fields, will not be effective if they are frequently flooded (Mazer, Booth, and Ewing 2001).

Scientific Uncertainty

Unless measurement is focused on effluent from a pipe, its accuracy will remain an issue in highly variable natural systems where a small signal must be distinguished from a large background level. Models are often used to estimate load reductions from BMPs. Whether they are developed with local measurements (empirical) or combine local measurements with mechanistic understanding of hydrologic principles and function (mechanistic), models are likely to provide estimates of nutrient load reductions with significant uncertainty (Reckhow 1994; Beck 1987; Olander et al. 2014). Natural time lags and high variability in the ways nutrients, warmed water, and sediment respond to management and move through watersheds make predicting the effects of non-point source management difficult (Meals, Dressing, and Davenport 2010).

Management Strategy:

- **Robust predictive models:** Uncertainty in crediting levels related to lags, variability, and science can be reduced or managed with robust predictive models that can better capture variability and time lags. Construction of such models may require local sampling and modeling expertise, the costs of which will usually be covered by a program during its design and development, rather than borne by regulated sources. States trading in the Chesapeake Bay Watershed—Maryland, Pennsylvania, and Virginia—are using a meta-analysis performed by researchers at the University of Maryland (Simpson and Weammert 2009) to improve estimates of the effectiveness of BMPs for the region. Virginia is applying effectiveness estimates to pollutant loading rates by land use and river basin from the EPA's Chesapeake Bay Watershed Model (Walker and Selman 2014). The U.S. Department of Agriculture has partnered with the World Resources Institute and the Texas Institute for Applied Environmental Research to develop a Chesapeake Bay Watershed version of the Nutrient Tracking Tool (NTT), a model to estimate agricultural nutrient and sediment reductions using on-farm characteristics and environmental factors (Selman et al. 2009). The NTT is usually calibrated to local data. Efforts are ongoing to improve the NTT and a variety of other models that could be used to estimate nutrient and sediment responses to management (EPRI 2011; Olander et al. 2014).

- **Direct measurement:** BMP effectiveness can be directly measured using methods like in-stream sensors. With this approach, sold credits could reflect observed reductions rather than estimates. Idaho's Lower Boise River Effluent Trading Demonstration Project recommends directly measuring reductions of agricultural BMPs designed to reduce phosphorus when possible (Ross & Associates Environmental Consulting Ltd. 2000). One risk of direct measurement is equipment failure, but this risk can be reduced or managed through quality assurance and quality control procedures to identify data irregularities and the need to replace faulty equipment. Direct measurement is currently not feasible for most nonpoint source BMPs but may become more feasible as the cost for in-stream sensors declines and the science improves (Olander et al. 2014; Burke and Allenby 2014).

- **Conservative crediting:** Uncertainty can also be addressed with a conservative crediting approach, whereby credit for each estimated unit of pollutant reduction is lowered when uncertainty is high (e.g., 1 credit for every 1.5 unit of reduction). The resulting ratio is sometimes called an *uncertainty ratio*. Virginia's Chesapeake Bay program uses a 2:1 ratio to account for scientific uncertainty, and Clean Water Services in the Tualatin Basin in Oregon uses the same 2:1 ratio to account for uncertainty in temperature reduction lag times (Vogel and Szeptycki 2012). The use of uncertainty ratios reduces the possibility that buyers will underestimate reductions and become noncompliant, but it will increase cost. A retirement ratio may also be used to withdraw some credits to ensure additional environmental benefit.

Effect of Management Mechanisms on Risks and Liability:
Robust quantification through improved modeling at the program level will reduce risk to programs (and the public) by increasing trust in them. Although direct measurement requirements could improve quantification, they could also increase sellers' costs and equipment failure risk. Equipment failure could result in an overestimation or underestimation of reductions and thus credits. Equipment maintenance and replacement costs could also be a liability for sellers. Such risks could be handled through insurance to cover equipment failures or services that maintain equipment and insure the results.

Risk of erroneous predictions about the benefits of an individual purchased offset is borne by the offset program, not by buyers. Technical risks and uncertainties can mean that predictions about reductions from non-point source trading do not match actual reductions in a watershed. If a watershed permit is in use, enforcement of the NPDES permit can involve audits and watershed sampling.[33] If there is a mismatch between predictions and reality, watershed sampling may not align with modeled predictions. If the models overestimate the load reductions from BMPs, the watershed sample may show a reduction less than that required by the NPDES permit, resulting in the regulated sector (the buyers) becoming noncompliant. However, this failure could owe to activities by other actors outside the trading program. If so, neither buyers nor sellers are held liable, but the regulatory program might ratchet down its requirements.

Extreme Events

Uncertainty associated with extreme events such as droughts, flood, earthquakes, and hurricanes can destroy the functionality of multiple BMPs in a region or watershed. For example, a drought could lead to the death of trees planted in riparian areas to provide shade for temperature credits, threatening the buyer's compliance that year and every year until the trees were restored or other actions were taken to reduce temperature. Even more troubling are events like the large floods like that alter the course of rivers, not only destroying BMPs but also changing the desirable locations for replacement BMPs.

Flooding events can be a challenge even if BMPs are not damaged. When water flow rates are high, the capacity of natural systems (buffers, wetlands) to process or store nutrients is diminished. Moreover, previously stored nutrients like phosphorus may move downstream with large sediment loads. In short, an increase in flooding events can undermine some types of BMPs (Fisher and Acreman 2004).

[33] Sampling can occur at the end of the pipe at one plant (individual permit) or at a designated location in a water body shared by point sources (general or watershed-based permits).

Management Strategy:

- **Resilient design**: BMPs can be designed to be resistant to or to maintain resilience to increasingly common extreme events such as flood, fire, and drought. Designing for the largest and least frequent of these events is likely not possible.

- **Force majeure:** Force majeure provisions limit buyer liability for project failures attributed to natural catastrophes such as flood, drought, disease, and pest infestation. These provisions either forgive the regulated entity's obligation due to acts of God, or, at a minimum, provide a reasonable timeframe for the entity and its credit producer to repair or replace lost projects (Freshwater Trust 2013). Force majeure events will not result in a permit violation.

- **Verification:** Annually credited projects will be verified regularly, allowing any damage to be captured before another year's worth of credits can be sold and protecting buyers but not sellers before credit sales. For permanent offsets in North Carolina, no further verification occurs after credit sales, and force majeure provisions address liability for losses.[34] In Virginia, permanent offsets for land conversion are reviewed annually using remote sensing.[35]

- **Assurance and maintenance mechanisms**: Like mitigation and conservation banks, permanent offsets can be required to carry financial assurances that will help cover maintenance and recovery of BMP function (NC DENR 2011, 2014).

- **Insurance pool/credit reserve**: Pennsylvania applies a 10% reserve ratio that goes into a state-managed insurance pool, which buyers can tap into if credits fail to materialize due to extreme events.

Effect of Management Mechanisms on Risks and Liability:
Resilient design of BMPs may reduce losses from extreme events, reducing risks for sellers, buyers, and the public. By limiting liability for credits sold and bought before extreme events, force majeure provisions help sellers and buyers but transfer losses to the program (public). Force majeure provisions will not protect sellers with unsold credits.

Verification of annually credited projects will capture any impacts on BMP function that continue into the next year and thus will provide an incentive for sellers to repair any damage to their projects and to ensure that buyers get fully functioning offsets. Projects that are part of multiyear contracts will need to be repaired to maintain expected credit generation (e.g., ID DEQ 2010). If these projects fail, contracts will need to be canceled and payments remitted, or replacement credits will need to be found.

Where they exist, assurance and maintenance mechanisms for permanent projects provide some resources for projects to recover from extreme events, and sellers are protected by force majeure provisions from having to spend additional resources on previously sold credits.

[34] North Carolina's program for use of buffers for water quality benefits requires permanent protection and long-term financial assurance (NC DENR 2011, 2014).
[35] Sarah Walker (World Resources Institute), to the author, October 14, 2015.

Overall, sellers would still face the risk of damages to their projects and the expense to address them if they have unsold credits. They will need to restore the BMP to have credits to sell. Permitted sources (buyers) are also likely to feel the pinch in the years following an extreme event, because the supply of credits may be lower than expected. The largest events, like those that change the course of rivers, can generate risk for sellers and potentially generate uncertainty about supply, which can also create risk for buyers.

Behavioral Uncertainty

BMPs can fail due to human error or mismanagement. A credit seller might not properly implement and maintain the credit-producing activity. Temporary or permanent failure could result from unexpected maintenance needs. For example, an invasive species may need to be removed from a vegetated buffer, requiring vegetation removal and temporarily reducing the effectiveness of the buffer. Adequate monitoring and management are needed to ensure that the annual management practices are in place and functioning as specified.

Management Strategy:

- **Advance project verification:** Many programs with non-point trading, like those in the Chesapeake Bay Watershed, require verification that projects are in place and operating before credits can be sold. Verification may be conducted by program administrators, certified third parties, a state agency, or project developers. Verification greatly reduces risks for buyers by ensuring that projects are in place and that some standard of performance is met before credits can be sold. Scheduled credit releases, which allow release of an increasing number of credits as projects become more established and effective, can also be used to reduce risk of project failure for both permanent and annual credits.

- **Permanent protection and assurances**: There is a movement toward permanent water quality credits for permanent loads from land use conversion. North Carolina's water quality program is currently focused on permanent stormwater offsets. It requires a permanent easement and assurances similar to what those found in mitigation banks (NC DENR 2011, 2014). Virginia recently started allowing use of permanent credits, which requires a conservation easement or other permanent protection to be attached to the deed (VA DEQ 2014a, b). Maryland is moving in a similar direction (WRI 2014).

- **Shared financial liability**: Sellers who are financially on the hook for the offsets provided by their credits have an incentive to make sure BMPs are operating properly and are well maintained.

Effects of Management Mechanisms on Risk and Uncertainty:
Buyers should be protected from most risks by purchasing verified credits. Sellers bear responsibility for maintaining functioning projects and thus bear much of the risk. There is some certainty about the extent of sellers' cost and potentially a limit to their liability when projects producing permanent credits use endowments or non-waiting funds tied to specific maintenance and adaptive management plans.

Restrictions and liability tied to easements will fall to the landowner or land manager, who may not be the project developer and seller. Landowners do face an opportunity cost risk where permanent easements are used.

Regulatory Uncertainty

Regulatory uncertainty remains an important issue for water quality trading. For example, despite successful temperature credit trading programs in the Rogue and Tualatin river basins, lawsuits initiated by point sources have held up trading for the rest of the Willamette River Basin (Willamette Partnership 2012). Regulatory uncertainty creates risk for programs (regulators); for regulated permittees, whose permits with traded credits could be invalidated; and for sellers who invest in water quality projects.

Management Strategy:

- **Clarifying regulations**: Despite significant effort by the EPA to clarify how water quality trading complies with federal law (EPA 2009), federal and state clean water regulation and a lack of case law leave some uncertainty about the implementation of water quality trading (e.g., Rowles and Thompson 2006; NEA 2015). This uncertainty may create barriers to trading if lawsuits question the legality of trading programs. Clarifying state law and using state law rather than federal law to implement these programs may be one way to reduce this risk.

- **Standard operating procedures**: Very specific and detailed operating procedures, regulations, and rules as well as clear project standards and best practices that are transparent to buyers and sellers can reduce uncertainty. Clarity about how impacts and credits are calculated will help buyers and sellers make less risky decisions.

- **Grandfathering early actors:** Rules that clearly grandfather in credits from early-actor projects can generate certainty for project developers and credit supply at the outset of a trading program.

- **Certainty programs:** Like safe harbor programs that exempt landowners who act to protect species from future regulation, certainty programs protect participants in trading programs from regulation from a defined period of time. These programs are developing in Virginia and Maryland (Willamette Partnership, WRI, and the National Network on Water Quality Trading 2015).

Effects of Management Mechanisms on Risk and Uncertainty:

While federal and state policy for water quality trading is in development and facing legal challenges, programs are moving forward. Regional trading programs are being designed to give buyers some certainty about their need for credits, but potential credit supply and costs will be less clear in emerging markets than in mature markets. Programs are also working to develop clear protocols so that sellers can estimate the number of credits they will receive and have confidence that those credits will be valid once a project is complete. Sellers are gaining confidence that state policies will be in place and drive demand for their credits.

During the time that projects are getting established, sellers need some certainty that their potential to receive credits will not be reduced. This need can be met by allowing projects to receive credits for a guaranteed period (e.g., five years) on the basis of the rules that were in place when they were certified, even if the rules are updated and credit values for an activity fall for some reason (e.g., scientific findings).

Regulatory uncertainty is a greater challenge early in market development, and many of the larger water quality trading programs are quite young.

Market Uncertainty

If permitted sources (buyers) plan on using credits to meet compliance needs rather than making changes to their infrastructure, a lack of credits or high credit prices could be problematic. Low credit supply and high costs can be addressed in part by providing certainty for project developers that demand will be sufficient.

Management Strategy:

- **Expanding market opportunities:** Opportunities for those involved in water quality trading to develop other types of credits are emerging. In Oregon, project developers are allowed to sell both temperature and salmon credits from different parts of their projects (Willamette Partnership 2009). In the Ohio River Basin Trading Project, project developers are allowed to sell both nitrogen and phosphorus credits from their projects (EPRI 2012b). Participation in multiple markets can help developers (sellers) to hedge risk but can also have high transactions costs.

- **Demand-and-supply projections**: Regulatory programs can project likely demand for credits over time by considering trends in point source releases and non-point source expansion. An analysis for the Chesapeake Bay region in 2010 found most trading basins in the region would have significant demand for non-point source credits and potentially sufficient supply (Selman, Sprague, Walker, and Kittler 2010).

- **Changing rules:** Programs with relatively few types of allowable or feasible BMPs will also have limited market opportunities. This market constraints might be addressed through changes in rules and regulations but not by buyer and seller actions.

- **Exchange**: Development of an online or easy-to-use clearinghouse or exchange to increase transparency of existing demand and supply data will reduce uncertainty (Walker 2011). Maryland is transitioning its trading platform to a multistate platform—the Chesapeake Bay Nutrient Trading Tool and Registry—which includes Pennsylvania and Virginia.[36] Another example is PENNVEST, a nutrient credit clearinghouse in Pennsylvania, which is used to coordinate auction sales, making credit-generating projects more viable for credit sellers by facilitating a connection to buyers (PENNVEST 2011). High credit supply with low costs will

[36] See "Maryland Nutrient Trading" at http://www.mdnutrienttrading.com/.

likely be self-correcting in the marketplace if supply and demand and purchase prices are sufficiently transparent.

- **Purchase guarantee (not yet used):** In the establishment of new programs in which nonpoint source credits are likely to be important, purchase guarantees (purchase of a guaranteed number of credits at a minimum price) could potentially be used to help develop supply, providing certainty to sellers and buyers (Walker and Selman 2014).

Effect of Management Mechanisms on Risks and Liability:
Increasing opportunities for project developers to access multiple markets, whether through selling different parts of their projects or through stacking multiple credits for a single activity, can help reduce risks for sellers and may lower the costs of credits for buyers over time. Current transactions costs of playing in multiple markets and uncertainty about staking rules limit these opportunities.

Regulatory uncertainty that persists for many developing water quality trading programs (see above) will lead to uncertainty about credit demand and supply. Purchase guarantees are one mechanism that could help to reduce this initial uncertainty, providing certainty for sellers thus generating supply, which may help reduce market uncertainty for buyers.

Regulators have the power to adjust baseline condition requirements, and types of BMP projects that are allowed in their watershed or state, to adjust credit supply, so long as they are still meeting legal requirements. This power may allow them to address predicted shortages or oversupply of credits. Market information found in supply-and-demand projections or exchanges also helps to provide transparency and reduce uncertainty for buyers and sellers.

Managing Remaining Risks

Despite the wide range of mechanisms used in the design of water quality trading programs to manage potential uncertainties faced by buyers and sellers, some risks remain. Many of these risks can be managed through additional mechanisms set up by buyers or project developers outside water quality trading programs.

Vertically Integrated Program

In a vertically integrated program in which buyers and sellers are closely coordinated and overseen by one organization, like that developed and implemented by Clean Water Services in Oregon, the regulated buyer is also an aggregated buyer, standard setter, and verifier of projects (Cochran and Logue 2010). This arrangement gives buyers control over risks and helps to ensure a credit supply to meet demand.

Private Buffers/Retirement Ratio

Extra credits can be set aside by buyers or sellers to cover remaining risks. Buyers, like water utility associations or individual point sources, can buy extra credits to set aside to ensure they meet compliance goals, but without banking provisions that allow them to use credits in future years, they may end up retiring any extra credits they hold. Buyers can also require a small risk ratio on all credits they purchase. This risk ratio is similar to the uncertainty ratio but may cover a broader range of risks and uncertainties.

Aggregators and project developers also often create their own buffers by developing more credits than they sell.

Diversified Project Portfolios

Buyers and sellers can also address risks by having portfolios with a variety of BMP types in multiple locations. Diversified portfolios hedge risks related to behavioral uncertainty, extreme events, and perhaps even regulatory uncertainty if rules on crediting change.

Transfer Risk Through Contracts

Buyers are the permitted entities required to meet reductions, but purchase agreements with brokers or project developers for water quality credits can guarantee delivery of a specified number of credits at a specified price. These agreements transfer significant financial liability to sellers, requiring them to meet their contract agreement even if some of the uncertainties discussed above reduce the credits they generate or the cost at which they are profitable. Buyers can sue sellers for fines or penalty costs as well as for the undelivered credits (requiring the seller to provide them through generation or purchase) if sellers violate their contract.

Insurance

Insurance could help sellers address risks to projects before project reductions are verified and credits are sold (e.g., unmanageable project failures like pests that kill plantings) as well as cover the costs of rebuilding after extreme events. It could be designed to decline in cost and coverage as credits are sold and value is recouped. Ecosystem Insurance Associates and Lexington Insurance both have products that can function as financial assurance. However, insurance does not appear to have been used in water quality trading. It remains uncertain whether publically (federal- or state-) supported insurance could fill the gap. Insurance products associated with credits to protect buyers from risk, like those developing in the California carbon offsets market (Doan 2013), have not yet emerged for water quality credits.

Programmatic Adjustments

Given that water quality measurements in watersheds are used to assess compliance, water quality trading programs may have a way of tracking their impacts on water quality and their overall success over time. However, activities and phenomena outside the control of program may have a large effect, making the program's contribution difficult to detect. If a water quality trading program fails to meet its compliance objectives—even through no fault of the regulated community—regulators may reset compliance (permit) requirements in the hope that doing so will facilitate achievement of watershed goals. States can also hedge bets on a trading program, retiring some credits to create a net benefit or margin of safety to help guarantee a watershed will meet its improvement goals under the program. Maryland, for example, uses a retirement ratio of 10% for point source-to- non-point source trades (MDWMA 2008).

Synthesis

Liability and risk in environmental markets are somewhat differentiated by the type of offset most common in those markets. Wetland and stream mitigation banking and conservation banking tend to be similar to one another because they operate in markets that offer only permanent offsets and one-time sale of credits. In contrast, carbon offsets programs and water quality trading programs operate in markets that tend to be more diverse because they offer both annual and permanent offsets and thus manage risk in more varied ways than permanent-offset-only markets.

Liability

Wetland and stream mitigation banking and conservation banking programs allow a full transfer of legal liability from the permittee to the bank. In contrast, water quality trading programs and the California Compliance Offset Program both maintain buyer liability, such that the buyer is ultimately liable for compliance. However, buyers (the permittees) often transfer some of their risk through contracts requiring brokers or project developers to address any shortfalls in purchased credits and allowing permittees to sue for breach of contract. These differences in the handling of liability by markets offering only permanent offsets and those offering both permanent and annual offsets affect what mechanisms programs use to manage risk.

Mechanisms to Manage Risk

Programs designed to support environmental markets or credit trading have numerous mechanisms designed to reduce programmatic risk (risk that the programs fail to meet their objectives). Some of these mechanisms are specifically designed to reduce risks to buyers, sellers, and landowners, thereby fostering the market and perhaps reducing the cost of the regulatory program of which they are a part. Other mechanisms that are built into these programs to manage programmatic risk can have a significant effect on buyers and sellers. This paper covered all the mechanisms that may significantly affect risk to the main parties—buyers, sellers, landowners, and programs—whether or not these parties are the intended target.

Similarities

All of the markets reviewed here have multiple programmatic risk management mechanisms in common (Table 6). They all **require projects to be in place and to meet standards** before credits are transferred to buyers. Wetland and stream mitigation banks and conservation banks **tie release of credits to performance standards** achieved by the banks and call for ongoing **monitoring** to ensure performance is maintained. Carbon offsets markets and water quality trading markets primarily use **verification and reporting** to ensure that projects have followed rules and protocols before any credits can be sold. All the markets have project registries to track the sale and retirement of credits to ensure that they are not reused.

Buyers and sellers in all the markets reviewed here use risk management mechanisms that are external to regulatory programs. One of these mechanisms is the **transfer of risk to the project developer**. Transfer of risk is a transfer of regulatory liability for wetland and stream banks and for conservation banks, but it is a transfer of legal and financial responsibility through the use of purchase contracts in carbon offsets markets and water quality trading markets. So the regulator would go to the banks (project developers) to address failures in the case of wetland, stream or conservation banks, but would go to the regulated

permittee for carbon or water quality trading markets. In theory, if buyers in carbon or water quality trading markets have contracts with sellers (project developers), they can sue sellers for fines or penalty costs as well as for undelivered credits (requiring the seller to provide them through generation or purchase) if sellers violate their contract. A number of other mechanisms are likely to keep this from happening.

Buyers and brokers in all of these markets also tend to hedge risk by having a **diverse portfolio** of projects. In addition, brokers and project developers, both of whom hold liability directly or through contracts, often maintain their own **internal buffer**—extra credits or acres in case they are needed.

Table 6. Risk management mechanisms explicit in program design (dark gray shading), implicit in program design (light gray shading), or outside program design (blue text)

General Mechanism	Markets			
	Wetland & Stream Mitigation	Conservation Banking	GHG Offsets	Water Quality Trading
Technical Risk				
Projects in advance of credits (benefit in place; credit release tied to performance standards; verified)				
Spatial planning (project placement; service area)				
Same type (impact = offset)				
Variable crediting (more credits required if project not complete)				
Variable crediting (given variable contribution across project area)				
Variable crediting (to account for model uncertainty) uncertainty ratio or retirement ratio				
Improve predictive models or use direct measurement				
Detailed measurement protocols or calculators for each project				
Transfer risk (project developers)				
Transfer risk (private insurance)				
Private buffers/diversified project Portfolios				
Extreme Events				
Force majeure for sellers (banks)				
Force majeure for buyers				
Adaptive management & assurance				
Remedial measures (suspend sale)				
Resilience planning				
Long contract length				
Program buffer (retirement ratio)				
Banking (allowances)				
Behavioral Uncertainty				
Project in advance of credit (benefit in place; credit release tied to performance standards)				
Monitoring and verification				
Site protection (e.g., easements)				
Management/maintenance plans				
Financial assurances				
Dispute resolution mechanism				
Management buffer (to protect from external risk)				
Long-term stewardship fund				

General Mechanism	Markets			
	Wetland & Stream Mitigation	Conservation Banking	GHG Offsets	Water Quality Trading
Certification				
Long contract length				
Banking				
Vertically integrated program				
Transfer risk (project developers)				
Transfer risk (private insurance)				
Private buffers/diversified project portfolios				
Regulatory Uncertainty				
Clear regulations (legal certainty)				
Standard operating procedures (banking agreement template, credit calculators, protocols)				
Grandfathering early actors				
Market Uncertainty				
Expand market (access to other market, broader area for trading)				
Reduce unequal competition				
Market exchange				
Banking				
Contract to lock in supply (reduce supply risk for buyers)				
Projections of supply and demand (public market analysis)				
Vertically integrated program				

Differences

Not surprisingly, the mechanisms used to manage risk across environmental market programs differ largely on the basis of whether offsets and credits are permanent or are periodic (temporary or annual commitments) (Table 6). While different terminology is used, permanent offsets credits across these markets tend to have a similar suite of embedded risk reduction mechanisms. In contrast, annual and periodic offsets, because they are not reversible and thus create a permanent benefit each year, do not require all the same protections.

Technical Risks

To manage technical risks, **variable crediting** is used in all environmental markets, but in different ways and for different purposes. In wetlands mitigation, a buyer could be required to purchase additional credits from a bank, if the bank is not fully established at the time credits are sold. For conservation banks, number of credits per unit of habitat will vary on the basis of habitat quality. And for carbon offsets and water quality trading, conservative crediting (erring on the side of caution by requiring the purchase of additional credits—requiring more than a 1:1 ratio) is used to address uncertainties in quantification.

All environmental markets have some type of **measurement protocol**. Carbon offset and water quality protocols require quantitative modeling tied to measurement to determine a specific measure of the provided function, for example, tons of carbon dioxide equivalents or pounds of nitrogen. In contrast, wetland and stream mitigation banks and conservation banks tend to be measured in terms of acres of habitat of a certain type and quality, both of which are assessed with rapid assessment tools and check lists.

Extreme Events

To manage the risk of extreme events, **force majeure** provisions are used to protect sellers (banks) in wetland, stream and conservation banks. But in water quality trading, these provisions are used to protect permitted buyers. This difference reflects the difference in how regulatory liability is held in these markets; the provisions protect those parties that would ultimately be liable for losses if not for the protection force majeure provides. Carbon offsets markets use a different method entirely, having all participants who are trading stored carbon offsets (e.g., reforestation, forest management) contribute to a shared **risk buffer** (insurance pool) that will cover the risk of stored carbon being lost. Those trading avoided emissions offsets, like avoided methane emissions offsets, that aren't at risk in extreme events are not covered. With this approach, the carbon offsets markets provide some protection that the California Compliance Offset Program can compensate for losses resulting from extreme events, reducing risks that the environment and the public end up paying them.

Another factor that may explain differences in risk management mechanisms is the potential for significant loss of expected benefits from extreme events. The potential that a forest fire will reverse all the greenhouse gas benefits gained from a reforestation project is high. Less clear is whether a flood will reverse benefits gained from a stream or wetland restoration project or that the stream or wetland segment that was being replaced would have fared any differently than the restored habitat.

Permanent offsets credits (wetland, stream, and conservation banks) include mechanisms like **adaptive management plans** and **financial assurance requirements.** As permanent offsets expand in water quality trading markets to address offsetting of permanent changes in land use, these markets are beginning to use similar risk management mechanisms. However some mechanisms like **remedial measure requirements** and **resilience planning,** which are explicit requirements, are only observed in conservation banking. The reason may be that the habitat and species that such banking is meant to protect are likely irreplaceable.

Behavioral Uncertainty

To manage behavioral uncertainty, all market used some form of payment for performance with verification or monitoring and **permanent site protection** (e.g., easements) for permanent credit types, but the other mechanisms used to augment these efforts vary. Wetland, stream, and conservation banks use **management plans** and **financial assurances**; conservation banks also use **dispute resolution mechanisms**, a **management buffer** to protect against behavioral uncertainty of neighbors, and **long-term stewardship funds**. The additional measures for conservation banks are likely viewed as important to protect irreplaceable habitat and species populations. For their carbon storage projects, carbon offsets programs use **long-length contracts** and a **forest certification requirement.**

Regulatory Uncertainty

All environmental markets programs have made efforts to clarify regulations, rules, and guidance and thereby lessen regulatory uncertainty. Nevertheless, less mature markets, like water quality trading markets, and markets affected by new rules, like the Clean Water rules that redefine some U.S. waters for wetland mitigation, may face legal questions which are not quick or easy to resolve. Most market-based programs develop **standard operating procedures** and user-friendly tools (e.g., credit calculators) to enhance regulatory certainty and consistency. Conservation bank are generally the exception; each bank is uniquely designed to address the specific habitat needs of the species of interest. One feature of each conservation bank is a **bank agreement** between the regulator and the bank sponsor that lays out the operating procedures for that bank. In California, some standard bank templates are being used, reducing variability across agreements.

Market Uncertainty

Wetland and species credit markets have a system that tracks unsold and sold credits but not prices. By contrast, carbon and water quality markets often have **exchanges** that include credit price information. All these markets also have ways to **project credit supply and demand** but not in the same way. In carbon offsets and water quality trading, facilitator groups (often NGOs) have conducted publicly available market analyses. In wetland, stream, and conservation banking, the bank sponsor organizations and businesses often have their own internal mechanisms for assessing potential demand and supply to assess their opportunities and risks. Given this, these market projections tend to be transparent and market wide for carbon offsets and water quality but proprietary for wetland, stream, and conservation banks.

Mechanisms to manage supply and demand risk vary. Wetland, stream, and conservation banks have explicit mechanisms that allow sellers and buyers to **expand their markets**. Bank sponsors can set up their banks to sell multiple kinds of credits, and in some cases they are allowed to sell wetland and stream credits at a higher trading ratio to neighboring watersheds outside their primary service area. Similarly, buyers may be allowed to purchase credits outside their primary service area at the higher trading ratio. These markets also have mechanisms to **reduce unequal competition,** given concerns that in the past activities with less certain outcomes were able to sell credits at lower prices. These mechanisms are less prevalent today because rules and common practice have changed. For carbon offsets, sellers can look to both regulated and voluntary markets for buyers, although lower prices may limit the desirability of voluntary buyers. Regulated buyers can look to purchase credits from a handful of project types from all over the country. For water quality, sellers have a geographically bound (by watershed or state boundaries) single market; buyers are also geographically bound, but they can buy from both point and non-point source sellers in many markets. Buyers and sellers across all markets can also manage market uncertainty by using private contracts to lock in supply or demand, respectively.

Mechanisms That Could Be More Widely Used

Increasing opportunities for project developers to **access multiple markets**, whether through selling different parts of their projects or through stacking multiple credits for a single activity, can help reduce risks for sellers and may lower the costs of credits for buyers over time. Wetland and habitat market rules make it relatively clear that banks can sell different portions of their bank into both wetland and habitat programs if properly permitted (Bean, Kihslinger, and Wilkinson 2008). How to sell into multiple markets is less clearly defined in water quality trading and carbon offsets markets, but the efforts of the

Willamette Partnership and the Ohio River Basin Trading Program may change this situation. The Willamette Partnership has established rules for allowing multiple credits from any one project. Its protocol generates multiple credit types for one area but reduces the remaining credits proportionately. The Electric Power Research Institute's (EPRI) Ohio River Basin Trading Program allows projects to sell both nitrogen and phosphorus credits and is exploring the addition of carbon offsets credits for nitrous oxide reductions (EPRI 2012b).[37] The transactions costs of participation in multiple markets and uncertainty about rules of such participation are constraining the growth of these cross-market activities.

The only ecosystems-based environmental market reviewed here that allows buyers to purchase credits and use them in future years—**credit banking**—is the California carbon offset market. This market allows banking of allowances and allows carbon offsets to be part of that system. Banking has been used in various emissions trading programs (Kling and Rubin 1997; Haites 2006), and it may be a useful way for buyers to buffer the risk that some of their expected supply fails to materialize. It also may provide protection from uncertainty in future supply, and it may create an investment opportunity for buyers if the value of banked credits increases over time. Banking may also provide an environmental benefit if that benefit is produced upfront—that is, before damages occur.

Banking may be a useful tool for markets with annual or term credits. Opportunities to use banking may be limited in other markets. Wetland, stream, and species markets do not use term or annual credits. Thus the only likely candidates for credit banking are carbon markets, in which that banking is already commonly used for annual allowances trading, and water quality programs.

At this time, **purchase guarantees** are not being used in any of the environmental markets reviewed in this paper. There is, however, an example of a purchase guarantee in the new stormwater trading market designed for Washington, D.C., that guarantees to buy credits if no private buyers come forward, albeit at relatively low credit prices.[38] Given that risk for developers (the suppliers) in environmental markets tends to be relatively high before credits are sold, purchase guarantees could be needed when demand is uncertain. Demand can be difficult to assess. In carbon markets, buyers can choose to purchase allocations from another covered entity instead of purchasing offsets. Similarly, in water quality markets, buyers can purchase credits from point sources instead of non-point sources. When demand isn't certain and suppliers are hesitant, purchase guarantees may be a useful risk management mechanism. They also could be a useful mechanism when regulatory and market uncertainty is hampering development of a supply of credits by keeping buyers away from the market. A program could guarantee the purchase of a limited number of credits at a set price to initiate trading and provide proof of concept. Purchased guarantees can also be provided as a backup plan for suppliers. Programs that provide purchase guarantees could hold the supply of credits they purchase and use them as a buffer to cover uncertainty and risks that could harm the environment and the public, or they could sell them back into the market when and if supply is low.

Vertically integrated programs, in which regulated buyers generate their own supply of offset credits by creating their own banks or BMPs, do occur periodically across markets. In high-risk markets, they could

[37] See http://wqt.epri.com/credit-stacking.html.

[38] See "Stormwater Retention Credit Trading Program" at http://doee.dc.gov/src.

reduce many risks. In more mature markets, they could increase the efficiency and effectiveness of highly specialized offset programs.

Proposals for a **credit bank** are discussed in the water quality trading community. The idea is to have a private or public centralized bank or clearinghouse that is an intermediary between buyers and sellers. Such a bank may centralize risk and provide efficiencies in connecting buyers and sellers, but transactions costs would be lost to the intermediary, and price setting could interfere with market dynamics and stifle third-party bankers from participating in a market (Walker and Selman 2014; Willamette Partnership et al. 2015).

A credit bank is similar in construct to an in-lieu fee (ILF) program, which has been used widely in wetland and stream mitigation programs but has been subject to many criticisms and failures (ELI 2006). The 2008 rules for wetland and stream mitigation suggested that private banks should be used preferentially, but also clarified rules for them. Efforts are being made to improve ILF programs and how they are used (ELI 2009). Some regions are using the programs as a backup option, accepting payments only when banks are not available in an area or requiring higher payments than banks in the same region. Another option is to use a credit bank as a clearinghouse that simply connects buyers and sellers but not to set prices or engage directly in the market. Such a mechanism was developed for the Washington, D.C., stormwater trading program.[39] It may be an alternative to help increase transparency and improve connectivity, but it may still have some impacts on market dynamics.

Closing Thoughts

Risk management approaches across environmental markets have more similarities than differences. These differences appear to be due to whether the markets offer only permanent offsets or a combination of temporary and permanent offsets rather than to the markets' investment in risk management. The other significant distinction is in the significance of the reversal risk for carbon storage offsets. Carbon storage offsets face a complete reversal of all accumulated greenhouse gas benefit. Other environmental benefits—aquatic or species habitat and nutrient retention—can be damaged in a flood or fire or prove to be less effective than expected, but the benefits are not all lost, and the protected areas or projects that provided them can be restored to full function. Thus the magnitude of the risk faced by the market program and the environment is higher for carbon storage offsets than for other offsets, and the mechanisms to manage risk reflect this reality.

Water quality trading appears to be the least mature market. It is the market with the most regulatory uncertainty, although the new clean water rule is generating some uncertainty for wetland and stream mitigation as well. Conservation banking leaves the greatest uncertainty for sellers (bank sponsors), given that aspects of each bank must be unique to the species of interest, with implications for what is required by the bank sponsor and how credits are calculated. The greater risks and uncertainties observed in water quality trading and conservation banking may explain why these markets have thus far experienced less robust trading.

[39] See "Stormwater Retention Credit Trading Program" at http://doee.dc.gov/src.

Appendix—Descriptions from *33CFR332.4(c)*

Adaptive management plan. A management strategy to address unforeseen changes in site conditions or other components of the compensatory mitigation project, including the party or parties responsible for implementing adaptive management measures. The adaptive management plan will guide decisions for revising compensatory mitigation plans and implementing measures to address both foreseeable and unforeseen circumstances that adversely affect compensatory mitigation success. (See §332.7(c).)

Financial assurances. A description of financial assurances that will be provided and how they are sufficient to ensure a high level of confidence that the compensatory mitigation project will be successfully completed, in accordance with its performance standards (see §332.3(n)).

Long-term management plan. A description of how the compensatory mitigation project will be managed after performance standards have been achieved to ensure the long-term sustainability of the resource, including long-term financing mechanisms and the party responsible for long-term management. (See §332.7(d).)

Maintenance plan. A description and schedule of maintenance requirements to ensure the continued viability of the resource once initial construction is completed.

Monitoring requirements. A description of parameters to be monitored in order to determine if the compensatory mitigation project is on track to meet performance standards and if adaptive management is needed. A schedule for monitoring and reporting on monitoring results to the district engineer must be included. (See §332.6.)

Performance standards. Ecologically based standards that will be used to determine whether the compensatory mitigation project is achieving its objectives. (See §332.5.)

Site-protection instrument. A description of the legal arrangements and instrument, including site ownership, that will be used to ensure the long-term protection of the compensatory mitigation project site (see §332.7(a)).

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