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Integrating Large-Scale Planning into Environmental Markets and Related Programs: Status and Trends

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Review
This working paper was reviewed by multiple government experts and an NGO expert. However, it has not undergone a formal review process. It is intended to stimulate discussion and inform debate on emerging issues.

SUMMARY

Federal government guidance on mitigation for environmental impacts recommends use of large-scale plans, preferably implemented in advance of impacts, to steer both development and mitigation. The idea is that advanced planning can improve site selection for proposed projects, increase return on investment for mitigation, improve predictability for project proponents, and reduce permitting times.

This study uses interviews with experts and a literature review to explore progress in integrating large-scale, spatially explicit planning into environmental markets and programs in the United States. It describes how the planning is guiding decisions about impact avoidance and compensatory mitigation, whether it is required or optional, and if it incorporates co-benefits or other regulatory-driven priorities. The assessed programs cover wetlands and streams, at-risk species, water quality, stormwater, greenhouse gases, and natural resource damages. They range from somewhat centrally planned programs, in which spatially explicit planning is more common, to distributed, market-based approaches, in which such planning is less common.

Large-scale planning appears to face few barriers to development and use, but its uptake may be limited by cost and time, uncertainty in the required spatial models, or insufficient proof of value. There has been little study of whether planning results in hoped-for improvements in investment return, environmental outcomes, or permitting time.

INTRODUCTION

On November 3, 2015 President Obama issued a memorandum "Mitigating Impacts on Natural Resources from Development and Encouraging Related Private Investment" that recommended the use of "large-scale plans" to guide the avoidance of impact to valuable resources and better selection of compensatory mitigation sites. In this memorandum, large-scale plans are defined as "any landscape- or watershed-scale planning document that addresses natural resource conditions and trends in an appropriate planning area, conservation objectives for those natural resources, or multiple stakeholder interests and land uses, or that identifies priority sites for resource restoration and protections, including irreplaceable natural resources" (Executive Office of the President 2015).

A goal of promoting a large-scale planning approach was identified as early as 1995, when 14 federal agencies signed a memorandum of understanding to promote an ecosystem approach across agencies for resource management (U.S. Department of Transportation 1995). Years later, the Department of Transportation (DOT) spearheaded a research effort with a number of other federal and state agencies to encourage a comprehensive approach to avoid, minimize, and compensate for impacts from infrastructure projects. Infrastructure projects, especially transportation projects, given their breadth and number, can generate significant cumulative ecosystem impacts. The DOT and other federal agencies recognized that compensatory mitigation from individual projects "may not be serving the highest ecological needs in a given area" (Brown 2006). The Eco-Logical framework they developed promotes prioritizing opportunities for advanced mitigation through integrated planning across agencies and resources (Brown 2006).

More recently, it has been widely recognized that a more comprehensive, landscape-scale approach to mitigation should support predictability, efficiencies, and better environmental outcomes than a project-by-project approach (Wilkinson et al. 2009; Kiesecker et al. 2010; Thorne et al. 2009). This type of planning approach is not new; State Wildlife Action Plans have been in development since 2000. Early on, however, regulatory agencies often lacked a framework for how to utilize existing landscape-scale plans to guide their mitigation decision-making (Wilkinson and Bean 2008; Wilkinson et al. 2009). Such frameworks have since emerged providing guidance on how to integrate large-scale conservation plans with application of the mitigation hierarchy (Kiesecker et al. 2010). Guidance on how to apply large-scale planning to development decision-making has become more widespread in implementing transportation projects (Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix 2014) and in wetland and stream restoration (Environmental Law Institute and The Nature Conservancy 2014).

This paper focuses on large-scale regional or local plans that use spatially explicit watershed or landscape-scale analysis that is created or selected by the program. The plans can be conservation oriented, suggesting where to avoid impacts and site compensatory actions. They may also identify restoration priorities and mitigation plans, suggesting where projects (protection, restoration, management) can provide the best environmental return on investment (best environmental outcomes for a given cost).

The paper focuses primarily on spatially explicit planning efforts rather than the use of watershed or habitat guidelines, which may indicate locations or habitat types of interest but which are not

typically spatially explicit. Although such guidelines can make important contributions to large-scale planning and can identify landscape-scale priorities, they often do not allow for the same degree of optimization and assessment of return on investment as spatially explicit planning. Many development and mitigation decisions are driven by the availability of land, which can limit the ability to optimize planning, but many relatively large programs are looking to prioritize objectives across watersheds and landscapes.

A few of the leading examples of large-scale planning in mitigation decision making have been well documented. This paper goes beyond those reviews and examines where and how large-scale planning is being used in environmental markets, to guide compensatory mitigation and related programs. It explores how large-scale plans are used to guide mitigation decisions in a variety of federal programs that affect private lands, including those related to wetlands and streams, species, water quality, stormwater, greenhouse gases, and natural resource damages.

The paper explores whether these large-scale plans include broad conservation objectives and multiple stakeholder interests, as suggested by federal guidance. It also seeks to determine if and how the plans are being used, for example, to identify avoidance areas and priority areas for restoration or protection. In addition, it explores whether there is evidence for reduced permitting time where large-scale planning is being implemented. It has been suggested that large-scale planning can help balance environmental protection and management with the need for development by reducing permitting times for both impacts and mitigation (Thorne et al. 2009).

This paper is designed to be a survey, not a comprehensive or systematic assessment, of the use of large-scale planning in current programs. It focuses particularly on spatially explicit prioritization plans but also notes the use of less spatially explicit watershed-planning guidelines. The objective is to move beyond the relatively well-known examples to better understand the current use of large-scale planning and to begin to identify potential barriers to and opportunities for expanding its use.

Methods

This paper explores the use of large-scale planning in the following federal programs: wetland and stream mitigation, endangered species mitigation, water quality management, stormwater management, greenhouse gas (GHG) mitigation, and natural resource damages. The first stage of this project involved a literature review and conversations with a few experts knowledgeable about the programs of interest. This initial scoping was used to develop a series of questionnaires targeted to each program type of interest. These questionnaires were sent to a diverse set of experts in each type of program, including experts from resource and permitting agencies, non-governmental organizations, mitigation providers, and private industry (see Appendix A). The questionnaires elicited valuable information about the use of large-scale planning initiatives but little information about their environmental outcomes because many of the initiatives are new and their outcomes are not tracked.

In the second stage of the project, experts knowledgeable about examples where large-scale planswere already in use were interviewed (see Appendix A). They were asked about how the plans were used, which types of programs the plans were used in, what kinds of information were incorporated into the plans, and whether the plans encouraged consideration of multiple benefits or regulatory requirements. Each expert was also asked whether there was any evidence

of increased regulatory certainty, reduced permitting time, improved environmental outcomes, or unintended negative consequences. Responses were supplemented by a review of publicly available plan and program information.

The examples summarized in this paper (and described in more detail in Appendix B) reflect a relatively robust initial screening that allowed identification of trends within and across programs. Notably, many of the identified large-scale plans or tools identified could be applied to more than one program, such as both wetlands and species mitigation. As a result, plans are categorized on the basis of our understanding of the primary motivation for their development.

WETLAND AND STREAM MITIGATION

As a component of the Clean Water Act (CWA), the federal government has established a goal of "no net loss" of wetlands (U.S. EPA 1990). Under section 404 of the CWA, the U.S. Army Corps of Engineers (hereafter "Corps") is directed to manage projects that impact the waters (both wetlands and streams) of the United States by directing permittees to first avoid or minimize impacts and then to compensate for any unavoidable impacts to the extent practicable. Three avenues are available for permittees to satisfy their compensatory mitigation obligations: permittee-responsible mitigation (PRM), in-lieu fee (ILF) programs, and mitigation banks (banking) (33 CFR 332).

New rules were finalized in 2008 by the Corps and the EPA that require the Corps to utilize a watershed approach when making compensatory mitigation decisions. This approach "involves consideration of watershed needs, and how locations and types of compensatory mitigation projects address those needs" (33 CFR 332.2). These approaches should also consider "the habitat requirements of important species, habitat loss or conversion trends, sources of watershed impairment, and current development trends" (33 CFR 332.2). When an appropriate watershed plan is available, the Corps should use it .[1] When one is not available, the agency should use available information that helps it make decisions in a watershed context.

Several states have developed guidance to support the selection of compensatory mitigation sites using a watershed approach. The Washington State guidelines, for instance, walk permittees through the mitigation site selection process (Hruby, Harper, and Stanley 2009). Because these guidelines are not designed to prescribe specific sites, they rarely include specific maps or priority watershed areas; instead, they describe the characteristics that would make a good mitigation site, including its watershed context. Although often not expressly required, mitigation projects of any type are much more likely to be approved when they follow the guidelines. This example of site-level consideration of watershed needs does not provide a spatially explicit prioritization strategy.[2]

[1] The guidance defines a watershed plan as "a plan developed by federal, tribal, state, and/ or local government agencies or appropriate non-governmental organizations, in consultation with relevant stakeholders, for the specific goal of aquatic resource restoration, establishment, enhancement, and preservation. A watershed plan addresses aquatic resource conditions in the watershed, multiple stakeholder interests, and land uses. Watershed plans may also identify priority sites for aquatic resource restoration and protection" (33 CFR 332.2).

[2] For this reason, Washington State emphasizes that, where watershed plans exist, "mitigation sites should be located in areas targeted by those plans for restoring ecological processes" (Hruby, Harper, and Stanley 2009).

For wetland and stream mitigation plans, this review found examples of spatially explicit watershed-scale prioritization and multi-benefit plans and tools of three dtypes: compensation planning frameworks, wetland prioritization tools, and comprehensive advanced mitigation plans (Table 1).

From interviews with users and publicly available documentation, five characteristics of each plan or tool (Table 2) were assessed:

- *Priority watershed map:* does the plan provide a map that delineates specific targeted regions for action?
- *Scope of application:* how is the plan intended to be used?
    - *Impact avoidance:* does the plan indicate areas to avoid (ideally in a spatially explicit map) to reduce impacts in priority conservation areas?
    - *Priority development:* does the plan specify regions for development (ideally in a spatially explicit map) (e.g. regions that might have access to a streamlined permitting processes)?
    - *Mitigation method:* does the plan apply to permits for mitigation including PRM, ILF or banking? Is use of the plan for mitigation required, encouraged, or neither?
- *Connectivity:* does the plan/map identify mitigation sites that are adjacent to or near existing conserved areas or other sites that are most important for maintaining connectivity of existing sites?
- *Services considered:* what other ecological or hydrological services (either at the site level or across the watershed) are considered in the watershed map or plan other than those explicitly required by the Clean Water Act? For instance, does the plan explicitly consider carbon sequestration, stormwater management, climate change adaptation, or impacts to the drinking water supply?
- *Regulatory overlap:* does the plan/map include information relevant to other regulatory programs, such as Endangered Species Act (ESA) or TMDL 303d listings?

Compensation Planning Frameworks for In-Lieu Fee Programs

In-lieu fee (ILF) programs provide an alternative mechanism to permittee-responsible mitigation and banks. Permittees pay a fee based on the extent and type of impacted wetlands (or streams), and government agencies or designated NGOs use those funds to enhance, restore, create, or protect aquatic resources. As of January 2017, 56 federally approved ILF programs existed across all or portions of 21 states (RIBITS). Nationally, roughly 10–15% of permits requiring mitigation since 2010 have utilized an ILF program (Vanderbilt, Martin, and Olson 2015).

Following the issuance of the 2008 mitigation rule, compensation planning frameworks (CPFs) became an integral part of any new ILF program. Consistent with the rule, CPFs require ILF programs to take a watershed approach to managing aquatic resources. Each ILF program must include "a prioritization strategy for selecting and implementing compensatory mitigation

activities," subject to approval by Corps district leaders (33 CFR 332.8(c)). As a result, any currently approved ILF program will maintain some level of watershed-scale prioritization. The guidance provided by the CPF applies only to selecting or siting mitigation projects funded by the ILF; it is not intended to influence development siting. CPFs can be tailored to individual state or regional objectives and can include other ecosystem services when relevant.

Many ILF programs utilize a guidance-based watershed approach. Rather than develop targeted restoration maps, CPFs for these ILF programs highlight specific wetland types or develop a ranking strategy for mitigation sites based on regional objectives. For example, both the Maine Natural Resource Conservation Program and the New Hampshire Aquatic Resource Mitigation Fund prioritize potential mitigation projects on the basis of pre-defined service area goals, including critical wildlife habitat or connectivity to existing preserved areas, but they do not highlight specific regions within each watershed for project prioritization (Maine Department of Environmental Protection 2011; USACE, New England District 2012).

Survey respondents identified only three ILF programs that utilize a spatially explicit approach to watershed planning through the use of priority watershed maps (Table 2). The King County (Washington) Mitigation Reserves Program identifies and maps a "roster" of potential mitigation sites on the basis of the sites' hydrologic and habitat characteristics (Murphy and Greve 2011). The Nature Conservancy, through The Virginia Aquatic Resource Trust Fund, uses an ecoregional assessment to establish maps of priority conservation areas to which ILF funds can be applied (The Nature Conservancy 2009). The North Carolina Ecosystem Enhancement Program identifies targeted local watersheds (at the HUC-14 scale) within each service area to which ILF funds are prioritized (North Carolina Department of Environmental Quality 2016).

Scope of Application

Given federal guidelines, CPFs are expressly designed to highlight the best places for mitigation, not impacts. When selecting sites for development, potential permittees could consider watershed criteria described in the CPF, but they are unlikely to do so without a requirement or incentive from the regulator, the Corps, through the permit application approval process. CPFs are designed to guide mitigation by ILF programs, which means CPFs do not guide permittee-responsible mitigation and mitigation banks.

Considered Services

Federal mitigation guidance requires consideration of aquatic resources, namely wetland acreage and habitat, but also impacts to water quality, in mitigation site selection. Habitat provision is also a key component of wetland function (Brander, Florax, and Vermaat 2006). As a result, it is not surprising that many CPFs indicate species and habitat connectivity as a priority in mitigation plan development.

ILF programs have the opportunity to advance other regional or state objectives in their CPFs through the consideration of co-benefits that might be provided by mitigation sites. For example, King County considers flooding risks and salmon restoration sites when developing its roster of mitigation sites (Murphy and Greve 2011). Notably, no ILF programs appear to consider carbon sequestration potential in their prioritization strategy.

Regulatory Overlap

Because the services provided by wetlands and streams are covered under a number of statutes, ILF programs can address the goals of other regulations, such as the Endangered Species Act (ESA) or section 303 of the CWA, which covers the setting of water quality standards for impaired waters. However, given the express requirements in the mitigation guidance, it can be difficult for CPFs to identify and bundle ESA mitigation opportunities. Recognizing this difficulty, King County developed recommendations for addressing impacts to endangered species alongside impacts to wetlands, although review is still performed on a case-by-case basis (Murphy and Greve 2011). Other ILF programs, such as North Carolina's Ecosystem Enhancement Program, expressly include assessments of water quality through the Total Maximum Daily Load (TMDL) designation when prioritizing areas.

Wetland Prioritization Tools

A few states and organizations have developed geographic information system (GIS)-based maps and tools for better assessing impacts to aquatic resources and prioritizing mitigation for greatest potential benefit. Interviews with experts identified three examples of wetland prioritization tools that are in use or under development: the Maryland Watershed Resources Registry, the Duck-Pensaukee (Wisconsin) Watershed Approach, and the Puget Sound (Washington) Characterization Framework (Table 2). These wetland prioritization tools can help users identify areas to target for specific watershed objectives.

These tools provide no single prioritization of sites, but rather a series of maps or sets of spatial data that can help users assess potential projects. Often the maps are tailored to specific needs, and rarely is their use required for a specific regulatory context such as an ILF program. These tools often provide a coarse-scale initial filter for site selection based on a user's specific objectives.

Scope of Application

The Puget Sound Characterization Framework categorizes "assessment units" for restoration, preservation, or development based on user-selected watershed criteria.[3] This categorization would be useful for any organization performing mitigation (PRM, ILF, or banks) (Stanley et al. 2015). Local governments have also used the tool to assist in land use planning for development.[4] The Maryland Watershed Resources Registry and the Duck-Pensaukee Watershed Approach are both designed to highlight prime opportunities for wetland preservation or restoration.

Use of the Puget Sound Characterization Framework, the Maryland Watershed Resources Registry, and the Duck-Pensaukee Watershed Approach is not required by the mitigation programs in each of these regions. But given that these tools were in part designed to link up federal, state, and local priorities, their use can help developers and mitigation agents align objectives with the relevant federal and state agencies. The coarse-scale level of analysis in these tools suggests they are used for selecting priority areas rather than specific sites.

[3] Assessment units are a homogenized spatial unit, which is the minimum scale of assessment in the framework.
[4] Several case studies can be found at https://fortress.wa.gov/ecy/coastalatlas/wc/landingpage.html.

Considered Services

Because these tools are often not tied to specific programs and regulations, they can consider a relatively wide range of services. For instance, the Duck-Pensaukee Watershed Approach provides an indication of carbon sequestration potential. The Maryland Watershed Resources Registry provides a map highlighting areas for stormwater infrastructure improvements.

Regulatory Overlap

Regulatory overlap is achieved where these tools utilize a wide variety of input data, including regional priorities such as listing of TMDL-impaired waters (Maryland Registry) or species recovery plans (such as salmon in the Puget Sound Framework).

Comprehensive Advanced Mitigation Plans

Interviews with experts elicted additional examples of state or regional plans developed to balance development and mitigation needs associated with wetlands and habitat (Table 2). The push for advanced mitigation has led some communities to take a proactive approach toward planning projects and performing mitigation that include large-scale, spatially explicit plans. Major infrastructure or transportation projects, given their breadth and need for mitigation, often drive development of these plans. The level of coordination required for the plans also encourages overlap with other regulatory requirements (see, for example, habitat conservation plans in Table 4). Engagement by a number of state and federal agencies such as the Corps also brings some degree of assurance for potential permittees, thus encouraging the use of comprehensive advanced mitigation plans despite their high costs of development.

Scope of Application

Comprehensive advanced mitigation plans are often developed in consultation with a variety of regulators, NGOs, and other stakeholders. They allow planners to identify watershed prioritization activities that meet regional needs. As a result, any mitigation method that can contribute to meeting these needs, including PRM, ILF, banks, and voluntary conservation, are encouraged (Erdle et al. 2001).

Local municipalities can incorporate advanced mitigation plans into planning ordinances. For instance, planners in southern Virginia have utilized the Southern Watershed Area Management Plan (SWAMP) to better avoid impacts to key wetland areas (Environmental Law Institute and The Nature Conservancy 2014). Similarly, when developing special area management plans (SAMPs), the Corps uses extensive ecological analysis to identify priority aquatic resources areas that should be protected as well as potential development areas with minimal watershed impacts (Camacho et al. 2016; Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix 2014).

When a SAMP has been developed, it can be a useful tool for guiding permits or mitigation activities. The Corps' Los Angeles District, for instance, has found success in using SAMPs in the San Diego Creek and San Juan/San Mateo Creek watersheds to protect habitat corridors while also streamlining permitting (Jae Chung, pers. comm.). Other examples of SAMPs used to identify advanced mitigation opportunities for transportation projects can be found in Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix (2014).

Considered Services

One benefit of comprehensive management plans is that they address specific local priorities. Plans described here originate from a need to manage watershed resources and thus focus on aquatic and terrestrial habitat as one component of aquatic resource health. Similar plans expressly designed for managing endangered species are described in the next section. The RAMP framework is unique in that regulators are using it to explore how to incorporate assessments of carbon sequestration into identifying mitigation opportunities (Regional Advance Mitigation Planning Work Group 2012).

Summary: Spatially Explicit Large-scale Planning in Wetland and Stream Mitigation

The 2008 mitigation rule generated renewed emphasis on using the watershed approach to guide site selection for wetland and stream compensatory mitigation projects. The 404 program does not, however, direct the Corps to develop watershed plans, nor does the agency's regulatory program have the resources to undertake proactive watershed planning. As a result, the watershed approach has been incorporated into compensatory mitigation decision making through the development of watershed guidance and watershed plans by state agencies, conservation organizations, and regional organizations. To implement watershed priorities, these groups have used various tactics: watershed-informed guidance, compensation planning frameworks, wetland prioritization tools, and advanced mitigation plans (Table 1).[5]

Table 1. Summary of watershed scale planning approaches in wetland and stream mitigation

	Opportunity for spatially explicit watershed prioritization	Prioritization approach	Designed for siting impacts (required?)	Designed for siting mitigation (required?)	Flexibility in services addressed
Watershed-informed guidance	No	Require consideration of watershed context using plans when they exist	No	Yes (encouraged)	No
Compensation planning frameworks	Yes	Maps of priority areas for mitigation	No	Yes (but only for ILF)	No
Wetland prioritization tools	Yes	Potential to create individual maps based on selected criteria	Yes (optional)	Yes (optional)	Yes; often for user-specified goals
Comprehensive advanced mitigation plans	Yes	Maps of priority areas for development and mitigation	Yes (required)	Yes (optional)	Yes; often address local priorities

[5] The planning approaches described here span the "watershed approach spectrum" described in the Watershed Approach Handbook (ELI and TNC 2014).

Watershed planning for wetland and stream mitigation can utilize watershed guidelines that are not spatially prioritized as in Washington State's mitigation approach. However, this paper emphasizes spatially explicit approaches. Table 2 summarizes how and when these spatially explicit planning approaches are used and what is included in them. All of the approaches use maps of priority areas for mitigation. All three CPFs highlighted provide a map of priority mitigation needs that the ILF program attempts to address. Unlike CPFs that deal only with mitigation, many comprehensive advanced mitigation plans also highlight priority areas for development. Wetland prioritization tools, on the other hand, can offer multiple maps based on the needs of specific users.

With the exception of CPFs, which guide the use of ILF funds, the other large-scale plans (compensation planning frameworks, wetland prioritization tools, and comprehensive advanced mitigation plans) are not required for siting mitigation projects, though many are designed to provide guidance for all types of mitigation (PRM, ILF, or banks). And, although not required, the use of the advanced mitigation plans may increase certainty and perhaps decrease permitting time for siting both development and mitigation.

Site selection for private mitigation banks is rarely driven directly by watershed plans. Instead it is driven by site-specific economic factors. However, considerations such as watershed connectivity and landscape features can be distinguished within a project narrative to help "sell" a potential mitigation site to the Corps (Chad Evenhouse, pers. comm., 6/7). In the case of SWAMP, bankers found that considering the plan in the site selection process helped garner goodwill from regulators by contributing to shared goals (Steve Martin, pers. comm., 5/17).

Perhaps because they are not explicitly required, and thus are not tied to a specific use, prioritization tools and the advanced management plans can be flexible in which services they address. Utilizing maps as a mechanism to highlight priority areas is a common strategy. With improving GIS capability and mapping tools, voluntary development of maps is likely to increase, and with it, consideration of additional ecosystem services. Although mapping and landscape/watershed prioritization tools can improve opportunities for matching impacts and offsets and for identifying opportunities to achieve multiple benefits and increase return on investment, they are often high-level assessments and do not preclude the need for on-site assessment. In contrast, advanced management plans are focused at smaller scales and thus produce higher-resolution prioritization maps.

Evidence for the impact of spatially explicit planning on ecological outcomes, permitting times, and regulatory certainty is lacking. However, anecdotal evidence offered by experts suggests that in many cases the time and effort required to develop spatially explicit plans is worthwhile. For example, the North Carolina Ecosystem Enhancement Program is often identified as a gold standard for encouraging advanced mitigation for North Carolina DOT projects in targeted local watersheds; North Carolina has performed successful mitigation in priority areas while streamlining the approval process for DOT projects (Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix 2014). Additionally, the Corps has found that in high-development areas, SAMPs can help maintain priority habitat while streamlining permitting. Other experts are hopeful that as watershed prioritization tools become more common their use in implementation of mitigation projects will expand.

Table 2: Applications of spatially explicit large-scale (watershed) planning in wetland and stream mitigation

Program	Priority watershed map	Scope of application						Considered services							Regulatory overlap		
		Impact avoidance	Priority development	PRM	ILF	Banks	Voluntary conservation	Connectivity	Wetlands	Habitat and species	Water quality	Carbon sequestration	Flood control	Water flows	CWA (404) wetlands	TMDL 303d	ESA
Compensation Planning Frameworks																	
VA Aquatic Restoration Trust Fund	✓				■			■	■	■					■	■	
NC Ecosystem Enhancement Program	✓				■			■	■	■					■	■	
King County (WA) Mitigation Reserves Program	✓				■			■	■	■			■		■		■
Wetland prioritization tools																	
Maryland Watershed Resources Registry				□				■	■	■	■		■		■	■	
Duck-Pensaukee Watershed Approach (WI)				□	□	□	□		■	■	■	■	■	■	■		
Puget Sound Characterization Framework (WA)			□	□	□	□	□		■	■	■		■	■	■		
Comprehensive advanced mitigation plans																	
Southern Watershed Area Management Plan (VA)	✓	■		□	□	□	□	■	■	■	■		■	■	■	■	
Special Area Management Plans (SAMPs)	✓	■	■	a				■	■	■	■				■		
Regional Advanced Mitigation Planning Framework (CA)				b		□		■	■	■	■	c	■	■	■		■

Notes: Dark blue indicates required and light blue indicates optional tool/plan use.

[a] When SAMPs are incorporated into mitigation plans by the Corps, they predominantly guide PRM.

[b] RAMP is being developed as a required mitigation tool for California Department of Transportation (Caltrans) projects. Mitigation and conservation banks are an optional mitigation method.

[c] California is considering how to incorporate carbon sequestration into advanced mitigation to further implement the California Climate Adaptation Strategy (Regional Advance Mitigation Planning Work Group 2012).

SPECIES MITIGATION

The Endangered Species Act (ESA) requires the U.S. Fish and Wildlife Service (FWS) or the National Marine Fisheries Service to issue a permit in order to grant the "take" of any listed species. 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). Permitting agencies allow for the "incidental take" of listed species from private actors under Section 10, as long as the impacts are minimized and mitigated .[6] Conservation banks, which much like wetland mitigation banks generate transferrable credits for conserving and managing habitat, are one mechanism by which permitting agencies allow for mitigation under Section 10, or for federal agency actions under Section 7 (U.S. Department of the Interior 2003). Increasingly FWS has also worked to engage landowners to voluntarily and preemptively protect species at risk of listing in exchange for assurances. These pre-listing activities encourage advanced conservation when it is likely to be cheaper (Donlan et al. 2013).

Federal and state agencies have long recognized the benefits of landscape scale plans to manage development and more effectively mitigate impacts to species and habitat (Mead and Wilkinson 2015). Effective planning can also help prevent the initial listing of a species under the ESA (or similar state statutes) and the resulting burden of regulatory permitting.

However widespread progress towards effective spatially explicit plans for species mitigation has been slow. The ranges of covered species can vary widely in size and often overlap. The conservation status of potential species can vary over time and across jurisdictions complicating the regulatory mechanism under which they might be managed. Species can require distinct habitat characteristics during different seasons or different lifestages. Taken together, these factors have resulted in a piecemeal approach to species and habitat mitigation and have limited progress toward landscape prioritization, especially when compared to wetland mitigation.

Despite these challenges, this analysis found three types of plans or tools designed to provide some level of spatially explicit landscape-scale prioritization for regional species mitigation: (1) private habitat conservation plans, (2) public habitat conservation plans, and (3) habitat exchanges. A generalized summary of opportunities for spatially explicit planning in species mitigation applications can be found in Table 3.

The following characteristics were assessed for each plan or program that uses large-scale planning (Table 4):

- *Priority habitat map:* does the plan provide a map that specifies targeted regions for habitat?
- *Scope of application:* how is the plan intended to be used?
    - *Impact avoidance:* does the plan specify regions where take permits will not be authorized due to the quality or type of habitat?
    - *Priority development:* does the plan specify regions that are favored for development?
    - *Mitigation development:* does the plan specify regions that are favored for mitigation actions?

[6] Incidental take results from actions that are not otherwise prohibited, "if such taking is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity" (ESA Section 10).

- *Mitigation method:* does the plan apply to permits for mitigation, including PRM, ILF, or banking?
- *Required/optional:* is use of the plan required, encouraged, or neither?

- *Connectivity:* does the plan identify or prioritize areas near other existing habitat or preserved areas or other sites that are most important for maintaining connectivity of existing sites?
- *Other species:* does the plan identify areas that are good for other important species not currently listed under the federal ESA?
- *Regulatory overlap:* does the plan identify areas that can be used to integrate mitigation requirements from other regulations such as Section 404 of the Clean Water Act?

Habitat Conservation Plans

Habitat conservation plans (HCPs) are required by the FWS for applicants to receive an incidental take permit for the taking of a listed species under Section 10 of the ESA. These plans must show that projects will not negatively impact the survivability of the species by identifying the projects' expected impacts and describing any mitigation actions (U.S. Department of the Interior 2003; Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix 2014).

Because HCPs deal with the planned impacts and associated challenges of a specific region, it is difficult to generalize about them (Lederman and Wachs 2014). HCPs can be used to guide development away from key habitat areas through fee structures or mitigation ratios (Lederman and Wachs 2014). They can also be used to identify priority areas for mitigation that addresses habitat connectivity or other key habitat features. These areas can be highlighted in habitat mitigation maps or emphasized through prescribed mitigation measures or ratios. Where they exist, some HCPs will emphasize the use of conservation banks or ILF programs.[7] Otherwise, mitigation is the responsibility of the permittee (Mead and Wilkinson 2015; Baldino, Olander, and Galik 2016).

The trend is toward large, multi-species, collaborative HCPs (Camacho, Taylor, and Kelly 2016). From a permitting perspective, these plans are often preferred because no individual consultation is required for any action covered under them (Lederman and Wachs 2014). Due to the expense and time commitment required, only two types of permittees typically go through the process of large-scale HCP development: consortiums of municipal or county planning and development departments (so-called public HCPs) and broad multi-impact development projects, especially energy and infrastructure projects (so-called private HCPs) (Baldino, Olander, and Galik 2016; Kiesecker et al. 2010; Langpap and Kerkvliet 2012). These development activities typically have long planning horizons necessary for collaborative HCP development. Due to the amount of land area covered and the length of the permit period, most large-scale HCPs address multiple species, including some not listed under the ESA (Lederman and Wachs 2014; see also Natural Community

[7] The Department of the Interior (2003) defines as conservation bank as "a parcel of land containing natural resource values that are conserved and managed in perpetuity, through a conservation easement held by an entity responsible for enforcing the terms of the easement, for specified listed species and used to offset impacts occurring elsewhere to the same resource values on non-bank lands."

Conservation Plans discussed below). As of June 2016, the FWS database listed 679 approved HCPs across all 8 FWS regions.[8] A 2012 analysis found that half of HCPs cover areas less than 5 acres; only 99 were greater than 1,000 acres. A majority of those larger HCPs were located in California or Nevada (Bergstein and Mo 2012). Highlighted here are six large-scale multi-species HCPs identified by experts as using a spatially explicit prioritization approach; two cover private infrastructure projects, and four are managed by regional or county development agencies (Table 4).

Scope of Application

Public multi-species HCPs are often managed by the regional governance body that developed them which enables them to mitigate more efficiently at scale (Lederman and Wachs 2014). The agencies or planning organizations that operate the permit have multiple options for funding mitigation. Some will extract fees from individual developers within the permit area, whereas others will leverage other sources of funding like taxes or bonds (Baldino, Olander, and Galik 2016). Adjusting these fees on the basis of location also provides an economic mechanism for guiding development away from priority habitat areas. By managing their own mitigation, regional agencies can prioritize additional management or habitat objectives while ensuring that covered species suffer no further loss.

In contrast, HCPs developed by private organizations (such as energy developers) are generally focused on efficiently achieving ESA compliance. This aim often leads them to utilize ILF systems or conservation banks so as to avoid having to perform mitigation themselves.

Almost all HCPs allow for the use of conservation banks as a mitigation method. But the large land area and number of species covered by many HCPs makes reliance on conservation banks difficult. Additionally, many private bankers may be reluctant to establish a conservation bank until after HCP approval, given the lengthy review and uncertainty inherent in the process (Travis Hemmen, pers. comm., 6/14).

Public HCPs are tasked with managing the demands of many individual developers. As such, specifying explicit avoidance areas provides clarity for developers and limits impacts in priority habitat areas. On the other hand, privately developed HCPs are more mixed in this regard. Private companies are less likely to focus on avoidance in their HCPs when they have already located their development (such as Columbia Pipeline Group in Table 4). However, in privately developed HCPs like Midwest Wind Energy, in which one permittee is responsible for multiple potential developers, avoidance areas are a necessary component.

Other Species

The ESA requires incidental take permits only for listed species. Many HCPs provide a mechanism for incidental take for a period of 30 or more years. HCPs are increasingly being designed to cover unlisted species due to the possibility of their future listing or to help prevent their listing in the face of increasing development (Lederman and Wachs 2014). Yet, planning for and monitoring multiple species concurrently can require extensive resources.

[8] The database can be found at http://ecos.fws.gov/tess_public/conservationPlan/.

In the 1990s, regulators in California recognized the need to develop a better system of species conservation, given the lengthy ESA listing and HCP implementation process. The Natural Communities Conservation Planning (NCCP) program was designed to provide proactive, eco-system-based planning to conserve the state's wildlife. A key feature of NCCP programs is that they allow for inclusion of any species, even species not yet listed under the state or federal endangered species acts (Pollak 2001). Nine NCCP programs have been approved in California; 14 more are in development.[9]

Regulatory Overlap

The extensive planning required to develop an HCP presents an opportunity to incorporate other environmental regulations. A number of HCPs attempt to streamline CWA Section 404 permitting by obtaining regional general permits from the Corps. However, the increased complication of managing requirements from multiple agencies makes aceiving multiple regulatory goals challenging (Lederman and Wachs 2014).

Habitat Exchanges and Other Developing Programs

New habitat credit or habitat exchange programs have been under development to engage private landowners in improving species and habitat conservation (Wolfe et al. 2012). By engaging in habitat conservation prior to listing, stakeholders can minimize regulatory restrictions that come with ESA listing. Once a species becomes listed, habitat exchanges are intended to provide an economically efficient way to promote conservation.

Many habitat exchanges utilize site-specific approaches to identify and assign credits to mitigation sites. For example, the Central Valley Exchange being developed in California to help restore and maintain habitat on private lands in California's Central Valley uses habitat quantification tools (HQTs), as do a number of other exchanges. For each of the four proposed covered species in the Central Valley, these tools will be used to evaluate site characteristics for inclusion in the exchange (Dan Kaiser, pers. comm., 6/28). Though not a method for spatially explicit planning, the HQTs incentivize some amount of landscape consideration through site-specific criteria.[10] The HQT developers are also discussing the tools' use within nearby areas with HCPs to better target mitigation or avoidance (Dan Kaiser, pers. comm., 6/28).

Spatially explicit plans were created for two species for which habitat exchanges and other conservation mechanisms are under development: the Lesser Prairie Chicken (LPC) and the Greater Sage-grouse (GSG) (Table 4). In the case of the LPC, the plan was developed by the Western Association of Fish and Wildlife Agencies (WAFWA) to proactively conserve habitat, thereby avoiding the need for listing (Van Pelt et al. 2013). In the case of the GSG, multiple states worked with the FWS to develop plans to avoid the need for listing (U.S. Fish and Wildlife Service 2014).

Scope of Application

In both cases, the spatially explicit plans were developed at a regional scale but the programs are implemented at the state scale. As a result, criteria for priority habitat are not consistent across borders, and states may utilize a variety of mitigation methods. For example, the WAFWA LPC

[9] A current list can be found at https://www.wildlife.ca.gov/Conservation/Planning/NCCP. The Western Riverside County and East Contra Costa County HCPs in Table 4 are two examples of HCP/NCCP combination plans.

[10] In the case of Swainson's hawk, the first of the HQTs to be approved by California Department of Fish and Wildlife, 30% of the site's score is a function of its landscape context (Stillwater Sciences 2016).

range-wide plan encourages developers to participate in a mitigation fund to offset their impacts to LPC habitat, though specific requirements vary by state. The plan identifies areas to avoid that are assigned a highermitigation fee if impacted. By guiding developers away from priority areas for conservation while also identifying priority areas for mitigation, mapping tools have resulted in clustering of development, thereby reducing overall impact (Van Pelt et al. 2013). The FWS GSG framework encourages states to utilize any available mitigation method and will use a strategic action plan that "will identify prioritized areas… to implement a landscape scale restoration effort" (U.S. Fish and Wildlife Service 2014). Nevada has an HQT for use in a habitat exchange program. Oregon has mitigation guidelines that rely primarily on permittee-responsible mitigation (see the appendix for further details), but it is considering development of an in-lieu fee program. It provides maps of core habitat areas and a framework for site selection that also includes assessment of other criteria such as risk of invasive species (Sage-Grouse Conservation Partnership 2015).

Summary: Spatially Explicit Large-scale Planning in Species Mitigation

Landscape-scale planning for endangered species mitigation is made challenging by the wide range of species needs, fluctuating regulatory requirements, and the many available strategies to satisfy species mitigation. These strategies can include habitat restoration or preservation, as in the case of wetland mitigation, as well as other activities or best management practices such as fencing or re-location. As a result, conservation plans must be tailored to specific species and regions, increasing the complexity of spatially explicit plans. As a result, conservation plans are often species specific. The best opportunity for development of plans that incorporate multiple species, both listed and unlisted, and that achieve overlap with other regulations are public HCPs with centrally managed mitigation.

Table 3 summarizes the three applications of spatially explicit landscape-scale planning explored by species mitigation programs. Table 4 summarizes how and when spatially explicit planning is used and what it includes. Although there are opportunities for spatially explicit planning in private HCPs and habitat exchanges, the best examples of such planning are in public HCPs.

Table 3. Summary of large-scale planning applications in species mitigation

Applications	Opportunity for spatially explicit land-scape prioritization	Prioritization approach	Designed for siting impacts	Designed for siting mitigation
Private HCPs	Yes, but not yet widespread	Often perform restoration with focus on lowest-cost restoration	No	Yes
Public HCPs	Yes	Regional development and restoration plans	Yes, provides centralized approach to development planning	Yes
Exchanges and ILF*	Yes, under development	Maps of priority areas for mitigation to guide credit exchange	Yes, ratios incentivize siting decisions	Varies

*Habitat exchanges, credit exchanges, or in-lieu fee mechanisms.

Table 4: Comparison of large-scale planning in species mitigation

Program	Priority habitat map	Scope of application					Connectivity	Other species		Overlap with CWA 404
		Impact avoidance	Priority development	PRM	ILF (Mitigation Fund)	Banks		Unlisted species	Listed species	
Private HCPs										
Midwest Wind Energy	a							1	6	
Columbia Pipeline Group	b						b	0	10	
Public HCPs										
Pima County (AZ)	✓	c	c	d				many	44	
Western Riverside County NCCP (CA)	✓			d				many	146	
East Contra Costa NCCP (CA)	hybrid[e]			d				many	28	
Iron County (UT)	✓			f				0	1	
Habitat Exchange and other developing programs										
Lesser Prairie Chicken - WAFWA RWP	✓	g	g					0	1	
Greater Sage-grouse - FWS Mitigation Framework	✓	h						1	0	

Notes: Dark blue indicates required and light blue indicates optional tool/plan use.

[a] The Conservation Fund is developing a mapping tool "to identify potential high value covered bat species mitigation site acquisition opportunities" (U.S. Fish and Wildlife Service 2016).

[b] The Conservation Fund has developed a green infrastructure mapping tool to help develop conservation corridors during the mitigation process; its use is not required, though heavily encouraged. See appendix for more information.

[c] Utilizes mitigation ratio to focus development in priority areas.

[d] In the case of regional HCPs, because the permittee is the county or regional planning body, this form of permittee-responsible mitigation is often called county-sponsored mitigation, to underscore that the individual developer is often not directly responsible for mitigation.

[e] The East Contra Costa HCP describes its approach as a hybrid approach "in which maps display conservation priorities on a regional scale. Land acquisition will be undertaken in accordance with a detailed set of requirements" (Jones & Stokes 2006).

[f] One of the preferred methods of mitigation in Iron County is the developer's translocation of prairie dog colonies to federal lands.

[g] WAFWA uses a system of fees and ratios to discourage development in priority habitat and encourage development where it already exists (Van Pelt et al. 2015).

[h] Most states use higher ratios to discourage development in priority habitat areas.

Localities have taken advantage of the centralized approach to development planning and mitigation inherent in public HCPs to implement comprehensive recovery plans. As habitat exchanges become more widespread, use of landscape-scale planning may increase in development of credit exchanges and trading ratios.

There has been limited analysis of the long-term ecological performance of HCPs, let alone those that focus on spatially explicit planning. Langpap and Kerkvliet (2012) found that HCPs, especially those that cover large areas, generally have a positive impact on species recovery. However, there is no evidence that multi-species HCPs are more effective than single-species HCPs. Once in place, HCPs are generally found to be effective at reducing permitting times, though the evidence is mostly anecdotal (Bergstein and Mo 2012; Lederman and Wachs 2014; Mead and Wilkinson 2015). No analysis has been performed specifically on HCPs that provide spatially explicit priority areas.

Because regional HCPs are often one component of a broad set of conservation goals, establishing their effect is difficult. However, the case of East Contra Costa County is worth noting. Following the great recession, demand for development than was less than anticipated. Yet regional officials continued acquiring lands to develop the preserve system laid out in the HCP. Compared with case-by-case mitigation, the HCP resulted in preservation of much more land (Dan Kaiser, pers. comm., 6/28).

Habitat exchanges provide a new opportunity to encourage voluntary conservation on private lands. However, the voluntary nature of credit supply can make it difficult to prescribe spatially explicit conservation strategies. HQTs and the habitat exchanges they support are often aimed at single species and tied to a specific region. Different states may utilize different landscape plans or conservation objectives. Developing the methodology, piloting the program, and obtaining approval from regulators can take multiple years. As a result of these hurdles, there are very few operational habitat exchanges and thus few opportunities to develop or use large-scale planning (David Wolfe, pers. comm., 6/15).

Water Management Programs

Under the Clean Water Act (CWA) states are tasked with identifying waters that do not meet water quality standards. For these impaired waters, often known as those on the 303(d) list, states must establish a total maximum daily load (TMDL) of pollutants at which that water body will meet the water quality standard. Under a TMDL, states must assess and allocate pollutant loads from both point and non-point sources for each water body (33 USC §1313; 40 CFR 130). Point sources are subject to additional federal permitting based on the TMDL, whereas non-point sources such as agriculture typically fall outside the authority of the CWA (Laitos and Ruckriegle 2012).

Stormwater runoff is managed under the National Pollution Discharge Elimination System (NPDES), a separate CWA program. To obtain an NPDES permit, localities must develop stormwater management programs describing what steps will be taken to minimize stormwater runoff (33 USC §1342).

Due to the lack of federal authority over non-point sources, states utilize a variety of mechanisms to achieve TMDLs and reduce stormwater runoff. These mechanisms include voluntary best management practices (BMPs), targeted improvement funds or trust funds, and water quality

trading markets (McElfish Jr et al. 2006). Recently, markets for trading stormwater runoff have emerged with a few operational examples around the country.

The programs, activities, and practices utilized to reduce pollutant and stormwater loads are all spatially assessed to consider their relative contribution to reducing overall loads to the impaired water body or drainage system. They could also be spatially prioritized according to which activities would most reduce loads. So the first question of this review is whether the best opportunities for meeting the primary water management objective (e.g., reduced pollutant, thermal, or stormwater loading) are identified and managed through planning or through market mechanisms (cost/unit of load reduction).

Water quality and quantity management practices can also offer environmental benefits beyond improvements to the targeted pollutant (Kieser and McCarthy 2015). For example, riparian buffer installation on agricultural lands may reduce the targeted nitrogen loading, while also reducing sediment and stream flashiness and providing carbon sequestration. So, the second question of this review is whether any of the programs include spatially explicit mechanisms to target pollution reduction projects to areas where they can contribute to secondary goals, such as stormwater reduction (in the case of TMDLs), habitat or endangered species management, or carbon sequestration. Combining goals could help to achieve other local or regional goals or to bundle outcomes that meet multiple regulatory requirements.

This study identified three program types for which spatial prioritization of load reductions (most reduction per cost), targeting of ecological co-benefits, or both were possible, though in most cases not yet ocurring: water quality trading programs, stormwater management programs, and water quality trust funds (Table 5).

Water Quality Trading Programs

Water quality trading programs are designed to achieve pollution (including temperature) reduction goals in a watershed at a lower total cost than traditional pollutant controls (Woodward and Kaiser 2002; Ribaudo and Nickerson 2009). Regulated facilities or point sources can purchase pollutant reduction credits from other actors, such as agricultural non-point sources, that are able to reduce pollution more cheaply (U.S. EPA 2007). To allow for trading, programs need to determine the pollutant reduction expected from a range of possible actions and locations—anything from new treatment technology at an upstream treatment plant to best practice management applications on a nearby farm.

Hydrologic conditions affect the fate and removal of pollutants from waterways; thus one pound of nitrogen upstream may not have the same ecological impacts of one pound of nitrogen at the mouth of the river (U.S. EPA 2014). Trading programs utilize watershed models to account for this inherent spatial variability in pollutant loading. In this way, water quality trading programs explicitly embed spatial information that will help identify the best return on investment for reducing regulated or targeted pollutants (Faeth 2000). If the models are robust and at sufficient resolution, it could be possible to use them to identify where projects would have the largest benefit or best return on investment (load reduction per dollar spent) (Tuppad, Douglas-Mankin, and McVay 2010). Water trading programs assume that a market mechanism will identify these least-cost same "best" projects without the need for a centralized planning process (Stephenson and Shabman 2011). We know of no studies that have tested this theory.

The second question concerns use of spatial planning to achieve multiple benefits. Despite the potential for multiple benefits from water quality BMPs (Gasper, Selman, and Ruth 2012), this analysis found only a couple of water quality TMDL trading programs that attempt to prioritize multiple ecological benefit projects.

Under the Chesapeake Bay TMDL, Maryland established its Nutrient Trading Program to offset expanded nutrient loads through the use of agricultural BMP offsets (see appendix). To date, no water quality trades have been transacted, but Maryland plans to implement a system to track carbon credits as well as relevant agricultural BMPs to make progress toward its statewide greenhouse gas reduction goals (Susan Payne, pers. comm., 7/13).

Another example, the Wastewater Reclamation Facility in Medford, Oregon, purchases temperature credits to help meet its TMDL temperature requirements (see appendix). Landowners generate credits in cooperation with The Freshwater Trust by planting trees to provide shade along the Rogue River Basin (Guillozet 2015). The Freshwater Trust prioritizes sites for planting on the basis of their thermal reduction potential as well as on their potential to improve salmonid spawning habitat and contribute to FWS species recovery plans (Julia Bond, pers. comm., 8/17).

Stormwater Management

Cities and municipalities are increasingly taking proactive steps to manage the flow of stormwater runoff within their jurisdictions to meet CWA requirements. The city of Philadelphia, for instance, has developed a comprehensive plan to target public funds to green infrastructure stormwater improvements (Fitzgerald and Laufer 2017). Other cities allow developers to meet stormwater requirements by paying an in-lieu fee, which can then be aggregated for city-wide improvement projects (U.S. EPA 2008).

Two municipalities, Washington, D.C., and Chattanooga, Tennessee, have developed stormwater credit trading programs to create opportunities for off-site stormwater mitigation (descriptions of each program can be found in the appendix). In these markets, stormwater credits can be generated by voluntarily installing stormwater BMPs within the program area. Regulated developers may meet a portion of the stormwater requirements through the purchase of credits rather than meet the entire required stormwater retention on site.

Much like water quality trading programs, stormwater credit exchanges utilize a market approach to achieve cost-efficient stormwater reductions. However, because they operate at a small scale, stormwater credit markets typically do not include an explicit spatial prioritization strategy for influencing where development occurs or offsets are generated; runoff retained anywhere within the program area is equally valuable. In Washington, D.C., the current economic conditions (i.e., land prices distribution, development demand, and BMP installation costs) have incentivized the installation of stormwater BMPs where the stormwater challenge is greatest, without any explicit push by regulators (Matthew Espie, pers. comm., 6/21).[11] Program developers did attempt one minor prioritization strategy: impacts within a designated Anacostia Waterfront Development Zone in D.C. require a higher trading ratio if credits are used from outside the Anacostia watershed (Center for Watershed Protection 2013), thus making credits from within this watershed more valuable. Additional priority watershed approaches are anticipated (Matthew Espie, pers. comm., 6/21).

[11] When the program was being developed, regulators anticipated this outcome.

The city of Chattanooga has attempted to target co-benefits in its stormwater exchange. The city implemented stricter runoff requirements for development within the South Chickamauga Creek watershed, home to the threatened Chickamauga crayfish, dis-incentivizing development in the region. However, stormwater credits from any watershed can be used as an alternative (City of Chattanooga 2014). In both of these municipalities, the stormwater credit programs are still very young and evolving.

Water Quality Trust Funds

A number of states have implemented a broad suite of loans, trust funds, and grants (collectively "water quality trust funds") to support the installation of BMPs to improve water quality. Many have federal support or cost-sharing provisions with the federal government, such as from EPA's Clean Water State Revolving Fund (Arbuckle 2013). The U.S. Department of Agriculture (USDA) also promotes a number of Farm Bill funding programs, such as the Conservation Reserve Program and the Environmental Quality Incentives Program, as sources of funding for water quality improvements on private lands.

Traditionally, these programs have used a site-specific approach to project selection, whereby projects are proposed and evaluated individually without watershed-scale prioritization (Scarlett 2011). However, as described in the wetland prioritization tools section, a number of states and organizations have developed maps or frameworks to improve targeting of wetland mitigation (Table 4). Many of these tools also aim to better target water quality improvements as well as a broad suite of BMPs, presenting an opportunity for their use by water quality trust funds. For example, the Maryland Department of Natural Resources has developed a spatial model to target state funds to high-priority watersheds with the lowest water quality and greatest potential for uplift.[12]

Scarlett (2011) highlights that many state and federal water quality trust funds provide opportunities for improving multiple ecosystem services in priority ecosystems. However, this study found that states primarily use a site-specific evaluation approach to granting funds and rarely consider ecosystem service benefits other than water quality improvements.

Summary: Spatially Explicit, Large-scale Planning in Water Management Programs

Table 5 provides a generalized summary of opportunities for spatially explicit planning in programs for water quality and quantity management. Although the TMDL and NPDES programs have been in place for decades, there has been less of a focus on watershed-scale planning in water management programs. Historically, water quality improvements were targeted to large point sources, which provided little opportunity for large-scale planning. As the emphasis has shifted toward nonpoint sources, states have utilized tactics such as trading programs and targeted funds to help meet water quality and quantity goals. However, the use of trading programs is not required, which limits their use and the need for spatial planning; water quality trading programs, for instance, are an optional compliance mechanism for point source polluters.

BMPs designed to reduce pollution from non-point sources often provide a number of co-benefits, but all programs identified in this study operate almost exclusively to maximize pollution reduction potential. States may feel hamstrung to focus solely on pollution or quantity

[12] The funds include state-level trust funds, like the Chesapeake and Atlantic Coastal Bays Trust Fund, and those available through federally driven programs like USDA's Conservation Reserve Enhancement Program.

reduction to make explicit progress toward their regulatory commitment (such as a TMDL). BMPs will likely be installed primarily on the basis of market conditions in both water quality and stormwater exchanges, unless program developers explicitly include consideration of co-benefits in program design—for example, by giving more credits to preferred BMPs that provide co-benefits or to BMP installation in preferred watersheds.

Table 5. Summary of large-scale planning in water management programs

Programs	Opportunity for spatially explicit prioritization	Prioritization approach	Designed for siting mitigation (required)	Opportunity to encourage co-benefits
Water quality trading programs	Yes, but limited in impact	Embedded in hydrological models	Yes (Yes*)	Yes, but limited implementation
Stormwater management	Limited due to scale	Opportunity to target through credit exchange ratios	Yes (No)	Yes, but limited implementation
Water quality trust funds	Yes, but rare	Maps of priority watersheds for BMP installation	Yes (No)	Yes, by specifying BMP selection or siting

*Yes, if regulated entities are using non-point trading. However, they are not required to use non-point trading.

GREENHOUSE GAS MITIGATION

In the United States, interest in greenhouse gas (GHG) emissions reductions to mitigate the impacts of climate change is growing. A number of state and regional activities, some market based and others more regulatory, provide opportunities for landscape-based GHG reductions (e.g., through the forest or agricultural sectors). As currently designed, programs under the authority of the Clean Air Act offer little opportunity for landscape-scale GHG mitigation (DeMeester and Adair 2015). But opportunities for GHG mitigation may also arise from efforts to incorporate GHG impacts into environmental impact statements and assessments at state or federal levels (CEQ 2016).[13]

Because greenhouse gases mix globally, the impacts of climate change felt at any place on Earth are a result of the planet's cumulative net emissions. Thus GHG reductions or carbon sequestration anywhere on Earth will contribute equally to stabilizing global climate. However, some locations (e.g., areas where carbon-dense forests grow) can contribute more per acre or more per dollar spent to global stabilization (Galik, Murray, and Mercer 2013). This reality presents an opportunity for a spatial prioritization of best regions or habitats for GHG reductions. So this study's first question is whether any programs are using spatial prioritization of GHG reductions as a primary strategy. Again, it must be recognized that market mechanisms may lead to this type of spatial optimization without the need for a centrally developed spatial prioritization.

[13] In August 2016, the CEQ released guidance on how federal agencies should consider the effects of GHG emissions of proposed impacts under the National Environmental Policy Act (NEPA). As with other NEPA reviews, agencies must consider the potential for GHG mitigation measures, which "could include enhanced energy efficiency, lower GHG-emitting technology, carbon capture, carbon sequestration (e.g., forest, agricultural soils, and coastal habitat restoration), sustainable land management practices, and capturing or beneficially using GHG emissions such as methane" (CEQ 2016). Albeit promising, the potential for landscape-scale mitigation measures is at this point unclear.

GHG reduction projects can have many non-target effects. Some projects can provide positive co-benefits (e.g., additional forest habitat (Deal, Cochran, and LaRocco 2012)), whereas others can have negative impacts (e.g., reduced habitat for migrating birds from changes in flooding of rice fields) that need to be addressed directly (Sesser et al. 2016). The potential for co-benefits presents an opportunity to bundle and advance other local priorities that can result from GHG mitigation activities (Deal, Cochran, and LaRocco 2012). Modeling analysis by Chan et al. (2006) found a significant overlap between carbon storage and water provisioning services and an opportunity to target biodiversity conservation through carbon credits in California. The spatial overlap of benefits suggests that developing landscape-scale plans that include these co-benefits might lead to opportunities to target GHG projects in regions that will help achieve multiple objectives (Qiu and Turner 2013). So, this study's second question is whether landscape-scale planning for GHG management includes or could include consideration of co-benefits, allowing GHG mitigation programs and investments to contribute to other goals.

On the basis of conversations with experts in the field, this study identified three types of programs that may provide an opportunity for spatial prioritization: (1) carbon offset markets, (2) regulatory compensatory GHG mitigation programs, and (3) targeted auction revenue funds. For each type of program, the study identified example applications that either offer a mechanism for spatial prioritization or have the potential to do so.

Carbon Offset Markets

Three regulated GHG markets exist in the United States: Oregon's program, California's program, and the regional northeastern U.S. program. Each offers an opportunity to implement carbon offset programs (Table 6). In a regulated GHG market, entities sometimes find it more cost-effective to reduce emissions off site through targeted offset projects developed by third-party providers than to implement emissions reductions on site. Offset projects include those that implement energy efficiency retrofits, produce renewable energy, or capture and combust methane (Hamrick and Goldstein 2016). Within the forestry and agriculture sectors, activities such as reforestation, avoided forest or grassland conversion, and no-till agriculture can generate GHG offsets by preventing the emission of greenhouse gases or by sequestering them (Murray 2015). The focus here is on landscape-scale planning and prioritization for forestry and agricultural offset projects.

In California's Cap and Trade Program under Assembly Bill 32 (AB 32), the use of offset projects, capped at 8% of total emissions, has been robust due to relatively high carbon prices. Conversely, in the northeastern Regional Greenhouse Gas Initiative (RGGI), offsets, which are allowed for up to 3.3% of a facility's obligation, have not been utilized to date (Murray 2015; Ramseur 2014). The Oregon Carbon Dioxide Standard requires covered power plants to meet an emissions cap and to develop offset projects or pay an in-lieu fee to the non-profit The Carbon Trust. As of 2014, all facilities had utilized the fee option to comply (The Climate Trust 2014).

Across offset markets, little emphasis has been placed on generating spatially explicit plans for generating GHG offsets; the assumption is that the private market will search out the best opportunities to obtain a good return on investment. None of the three studied programs target offsets for co-benefits. Within voluntary carbon offset markets, some buyers consider location or co-benefits of potential offset projects, but price remains the primary driver (Hamrick and Goldstein 2016; John Nickerson pers. comm., 6/29). Similarly, The Climate Trust, which manages

revenue from the Oregon Carbon Dioxide Standard, recognizes that offset projects can bring additional environmental benefits, but it prioritizes offset projects that provide cost-effective carbon reductions (The Climate Trust 2014).

Regulatory Compensatory GHG Mitigation

The state of California has two primary mechanisms to manage GHG emissions: AB 32 and the California Environmental Quality Act (CEQA). CEQA is a statewide environmental impact disclosure process (similar to NEPA at the federal level). Following passage of AB 32, CEQA was amended in 2010 to explicitly require proposed projects to assess their impacts on GHG emissions during the environmental review process (14 CCR § 15064.4). A similar approach has just been initiated at the federal level; the Council on Environmental Quality released guidance on how to consider and mitigate GHG emissions under the National Environmental Policy Act (CEQ 2016), but it will take time for implementation to take shape. In California, the Environmental Impact Report must describe the mitigation measures that will be taken to minimize GHG impacts. Appropriate mitigation measures for GHG impacts vary by project, but they can include alternative project siting to reduce vehicle miles traveled, reduced facility fuel use, or offset projects that sequester carbon (14 CCR § 15126.4).

In assessing GHG mitigation projects during a CEQA review, lead agencies are encouraged to consider the co-benefits. As a result, they have a preference for local or regional mitigation projects over national projects (Santa Barbara County Air Pollution Control District 2015). To better facilitate the use of offsets for CEQA mitigation, while also achieving other air pollution goals, the California Air Pollution Control Offices Association (CAPCOA) in 2014 established a registry of GHG mitigation projects within California (California Air Pollution Control Officers Association 2015). However, the number of available projects is low (Santa Barbara County Air Pollution Control District 2015).[14] The lack of a current statewide standard for landscape or jurisdictional mitigation measures limits their use (The Nature Conservancy and Sonoma County Agricultural Preservation and Open Space District 2016).

Concurrently, while updating CEQA, California also passed SB 375, the Sustainable Communities and Climate Protection Act. SB 375 tasks metropolitan planning organizations (MPOs) throughout California with preparing sustainable communities strategies (SCSs), a land use planning document, to better align regional GHG reduction goals with long-term transportation planning and conservation of natural lands (Greenway 2010; Livingston 2016). Funding through SB 375 for planning must show tangible GHG benefits (Karen Gaffney, pers. comm., 7/21). The law was designed to enable local planners to better facilitate land use planning as a way to manage GHG emissions from development, especially given the project-based mitigation approach of CEQA (Barbour and Deakin 2012). In fact, projects that are designed on the basis of SB 375 plans receive some relief from CEQA GHG impact reviews (Greenway 2010).[15]

An analysis of existing SCSs by Livingston (2016) reveals that recommendations made within SCSs are only just beginning to be implemented by local planning authorities as a way to combine

[14] The registry can be accessed at http://www.ghgrx.org/.

[15] As Greenway (2010) notes, "This relief is meaningful. Developers commonly point to a CEQA paradox: compact, infill projects reduce regional congestion by placing people closer to jobs and transit, but such projects seem like net traffic generators during environmental review because the law only requires quantification of the project's local traffic impacts."

conservation priorities with development planning and GHG reductions. Some MPOs have aligned their SCSs with existing regulatory programs such as HCPs (see HCPs in Table 3). Others are attempting to tie in to existing or to create new Regional Advanced Mitigation Planning (RAMP) programs that guide wetland and stream mitigation for transportation projects (see RAMP in Table 2).

Taken together, these policies provide a number of opportunities to promote a landscape-scale, spatially explicit approach to GHG mitigation in California. However, most of the mitigation effort has remained focused on clean technology, fossil fuel use, energy efficiency, and transportation improvements (Barbour and Deakin 2012; Santa Barbara County Air Pollution Control District 2015). As a result, only a small subset of mitigation effort has been focused on landscape-based comprehensive mitigation strategies to meet the climate objectives of AB 32 through CEQA.

Auction Revenues Funds

Enacted in 2006, California's AB 32 established a mandatory cap-and-trade program to reduce GHG emissions across multiple sectors that represent roughly 85% of statewide emissions (California Air Resources Board 2016). Aside from the market for allowances and offsets, discussed above, there are additional programs of interest. Under AB 32, a portion of the GHG allowances are auctioned to fund the Greenhouse Gas Reduction Fund (GGRF). This fund is designed to "facilitate comprehensive and coordinated investments throughout California that further the State's climate goals" while also providing "major economic, environmental, and public health benefits for Californians" (California Air Resources Board 2016). Funds are appropriated to a variety of projects, including those focused on clean transportation, sustainable communities, and energy efficiency. Natural resource-based programs have received a much more limited amount of funding (California Air Resources Board 2016).[16] Notably, California does not require the funds to be utilized in a way that optimizes the carbon benefit per dollar spent (John Nickerson, pers. comm., 6/29).

RGGI also utilizes an auction for roughly 90% of total allowances across its nine-state market (Ramseur 2014). Each state manages its auction revenue fund. The vast majority of auction revenues have been used for energy efficiency and renewable energy projects. The use of auction revenue for landscape-based or forestry GHG reduction projects that might provide co-benefits is very limited (Regional Greenhouse Gas Initiative, Inc. 2015).

In light of these opportunities, this study identified one specific example of a regional approach in California to target GHG reduction opportunities while also achieving other priorities that might benefit from auction revenues.

Sonoma County Agricultural Preservation and Open Space District

The Sonoma County Agricultural Preservation and Open Space District has been operating since 1990 to preserve natural resource and agricultural areas throughout the county in the face of urbanization. Since 2006, land acquisition and management by the district has been funded primarily through a quarter-cent sales tax. The district focuses its land acquisition on four categories: farms

[16] During the first three fiscal years of the fund, beginning in 2013, natural resource-based programs and agencies (Climate Smart Agriculture, Wetlands and Watershed Restoration, and Sustainable Forests) have received $144 million (or 5.5% of funds) (California Air Resources Board 2016).

and ranches; greenbelts and scenic hillsides; water, wildlife and natural areas; and recreation and education (Sonoma County Agricultural Preservation and Open Space District 2006). In collaboration with The Nature Conservancy, the district has begun to incorporate an assessment of landscape carbon into its acquisition strategy to help meet its goals under SB 375. The Nature Conservancy developed a jurisdictional carbon inventory tool to help the district better prioritize carbon storage alongside other conservation objectives (The Nature Conservancy and Sonoma County Agricultural Preservation and Open Space District 2016). The tool is designed to be a major factor in the upcoming update to the acquisition strategy (Karen Gaffney, pers. comm., 7/21). Incorporating carbon assessments into its acquisition strategy allows the district additional opportunities to access GGRF and SB 375 funds (Karen Gaffney, pers. comm., 7/21). Although the district hopes to take advantage of state carbon auction (or GHG reduction) funds, it does not plan to participate in offset markets and does not anticipate providing direct CEQA mitigation opportunities (Karen Gaffney, pers. comm., 7/21).

Summary: Spatially Explicit, Large-scale Planning for GHG Mitigation

Table 6 provides a generalized summary of opportunities for spatially explicit planning in programs for GHG management. Although co-benefits from GHG mitigation projects are often encouraged, they have not been formally integrated into planning or crediting. Many co-benefits can be achieved without the use of landscape-scale planning (Haines et al. 2010), but this paper focuses attention on use of such planning to inform how agriculture, forestry and land use can best achieve multiple goals. Competition for access to offset opportunities, compensatory mitigation projects, and auction funds is likely to be fierce, which may disincentivize a more costly, time-consuming landscape-scale approach. Nevertheless, CEQA has only considered greenhouse gases since 2010. If GHG regulatory mechanisms become more common at either the state or federal level, the potential for landscape-scale planning is likely to increase.

Table 6. Summary of large-scale planning in GHG mitigation programs that involve land use

Programs	Focus on primary emissions (impacts)	Focus on compensatory reductions (mitigation)	Spatial prioritization of GHG benefits	Spatial prioritization of co-benefits
Carbon offset markets	No	Yes	No	Very limited
Regulatory compensatory mitigation (CEQA & SB375)	Yes	Yes	Not yet, but may develop under SB375	Not yet, but may develop under SB375
Auction revenue-funded programs	Program focuses on overall reductions		Not yet, but likely	Not yet, but likely

NATURAL RESOURCE DAMAGE ASSESSMENT

Federal and state governments can seek compensation for damages to natural resources through natural resource damage assessments (NRDAs) under such laws as the Oil Protection Act (OPA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Under a NRDA, state and federal trustees are tasked, on behalf of the public, with estimating the

costs of and oversight of natural resource restoration (Curran 2015). NRDAs can cover a wide range of ecosystem impacts, and they may require mitigation for damages to wetlands, habitat, and water quality. Notably, NRDAs do not yet directly address damages for carbon emissions (Pendleton et al. 2013).

NRDA's objective is to ensure mitigation for damages to ecosystems and the loss of services these ecosystems provide. Although trustees might receive a greater return on investment if they use a landscape-scale approach to maximize the ecological return from NRDA funds, there is no evidence that large-scale spatial prioritization of mitigation actions has been utilized, given a number of constraints on trustees and available sites (Pieter Booth, pers. comm.,, 8/18). The recent settlement for the BP Deepwater Horizon oil spill highlights a potential opportunity to do so (see appendix). Given the extensive scale of the damages, the trustees in this case developed an integrated ecosystem restoration plan and governance structure to achieve a number of goals across the Gulf of Mexico (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). However, specific restoration plans are still being developed, and therefore the level of spatial prioritization that will take place in restoration is unclear (Michele Laur, pers. comm., 8/10).

One hindrance to developing landscape-scale plans under NRDA is that federal trustees are limited by their mandate to link restoration to a specific injury. State trustees may have more flexibility to incorporate local objectives (Pieter Booth, pers. comm., 8/18). Assessing the effectiveness of NRDA plans is also difficult given the litigious basis of their development; specific terms of any settlement are often confidential (Pieter Booth, pers. comm., 8/18).

CONCLUSION

This review explores how large-scale planning and prioritization is used in a range of resource management programs, including those with market-based program design. It assesses how large-scale spatially explicit planning is being or could be incorporated into such programs to avoid development projects in high-quality areas or to help mitigation projects improve return on investment by getting the most benefits—both those required by the primary program objectives and co-benefits where possible.

The clearest examples of large-scale planning are regional maps and plans that highlight opportunities for development, conservation, and mitigation, such as those being used in public HCPs (like Western Riverside County, California, and Pima County, Arizona) and wetland and stream mitigation (CWA Section 404) ILF programs that include spatially explicit priority maps, such as North Carolina's Ecosystem Enhancement Program (Table 7). These programs tend to be more programmatic, or centrally planned, than the others. The overlap with market-based programs is only seen in hybrid programs that merge programmatic and market-based approaches. Although comprehensive advanced mitigation plans like Virginia's SWAMP are often planned centrally, they succeed by creating incentives for mitigation providers, such as wetland mitigation banks and permittees responsible for mitigation, to direct their projects to priority sites identified in the plans. Those programs that are dominated by market-based mechanisms, like GHG offsets and water quality trading, use financial incentives and disincentives embedded in program design, rather than programmatic planning, to select sites that will provide the best return on investment. However, some of these more market-based programs can and are starting to use large-scale planning to design program incentives or crediting ratios to respond to spatially

explicit priorities, some of which may capture co-benefits along with the primary program objective. This trend is seen in a few programs like Washington, D.C.'s, stormwater trading program and the temperature credit trading program in Medford, Oregon.

Table 7. Overview of opportunities for large-scale planning approaches across programs

	Large-scale spatially explicit prioritization	General guidelines
Programmatic approach		
Compensation planning frameworks		
Wetland prioritization tools		
Habitat conservation plans		
California SB 375 GHG mitigation		
GHG auction revenue funds		
Hybrid approach		
Comprehensive advanced mitigation plans		
Habitat exchanges		
Water quality trust funds		
Market approach		
Water quality trading programs		
Stormwater trading programs		
Carbon offset programs		

Use of large-scale planning is in its infancy. HCPs have been used since the 1980s (Lederman and Wachs 2014), but the large-scale planning approach highlighted in the examples provided here is much more recent. Similarly, the first guidance for wetland ILF mitigation programs was issued in 2000, but only since the 2008 mitigation rule have CPFs been required and has a spatially explicit approach emerged. For these programs, expansion of planning is rapid. Similar expansion of a spatially explicit approach might soon be observed in GHG mitigation through California's SB375.

There appear to be many other opportunities to increase the use of large-scale planning in centrally controlled programs, particularly those that are regionally developed. Virginia's SWAMP highlights how this level of control allows regionally defined and developed objectives and hence an opportunity for prioritization that is more spatially explicit (rather than prioritation achieved through site evaluation tools alone. Regionally managed programs also often have greater flexibility to consider and include co-benefits and to attempt to incorporate other regulatory requirements, as observed in Maryland's Watershed Resources Registry. However, in other cases, the expected large-scale planning approach has not been observed. California's GHG Reduction Fund offers a prime opportunity to develop a large-scale prioritization strategy, but funding for landscape projects has been limited.

In market-based programs, the opportunity for large-scale planning lies in using spatial prioritization to set programmatic incentives (crediting ratios, faster permitting) or disincentives (relatively high impact ratios, delayed permitting). For example, Washington, D.C., uses a higher stormwater trading ratio to increase the value of credits generated within the Anacostia watershed, a high-priority area for economic and ecological restoration. As these examples suggest, the spatial resolution of such incentives and disincentives is likely to be a relatively coarse focus on specific regions of interest for protection or mitigation projects. This focus will likely better match the functional resolution of prioritization models. Less emphasis may be placed on developing large-scale plans for market-based programs, because a well-designed market should identify the cheapest opportunities for generating credits. However, the complexities inherent in mapping and managing multiple species or multiple populations of a single species lead to the conclusion that species-focused markets have the greatest need for a spatial prioritization approach to habitat. In contrast, spatial prioriatization appears less likely to be adopted in carbon offset markets, where modeling of carbon credits is relatively straightforward. A remaining question is whether there will be opportunities to integrate co-benefits into these markets. If so, spatial prioritization to find the overlap of the benefits might be important.

There are a few likely constraints and barriers to further use of large-scale planning in both programmatic and market-based approaches. First, there are significant limitations in models now used for spatial prioritization. Many have insufficient resolution or confidence due to critical data gaps (e.g., Merow et al. 2014)tree-based models, maximum entropy, etc.. Second, prioritization can be time consuming and require coordination and agreement by many decision makers and stakeholders. Third, there may be regulatory or legal barriers like those observed with NRDA, where those planning mitigation are limited in their implementation options. And fourth, many regulating agencies are not required or incentivized to develop such plans.

There appear to be numerous opportunities for federal programs to better incorporate large-scale planning to better target impacts and their offsets (mitigation), as called for in the 2015 White House memo. Some policies, like California's SB375 and the 2008 Compensatory Mitigation Rule's requirement for Compensation Planning Frameworks for ILF programs, call for such planning to be broadly implemented, but in most cases little progresshas been made. Although there are likely to be legal constraints to incorporating co-benefits not required by regulations for many programs (such as in NRDA), these constraints should not impede targeting of the primary regulatory objective (e.g., reduced pollutant loading). So, the question remains, what is limiting the use of large-scale planning? The answer may be cost and time requirements for planning and implementation, modeling uncertainty regarding selection of targeted areas, or perhaps limited proof of the benefits.

There has been little systematic study of the environmental or economic benefits that result from large-scale planning in these programs. It will be important to track permitting time and environmental outcomes where large-scale planning is integrated into programs to discover any improvements. Ideally, some variation among programs will allow more controlled experiments to really test how well large-scale planning achieves its goals of improving outcomes and balancing environmental and development needs.

APPENDIX A: METHODOLOGY AND EXTERNAL ADVISORS

This paper reviews the use of large-scale planning in the following federal programs: wetland and stream mitigation, endangered species mitigation, water quality management, stormwater management, GHG mitigation, and natural resource damages.

The first stage of this project involved a literature review and conversations with a few experts knowledgeable about the programs of interest. This initial scoping was used to develop a series of questionnaires, targeted to each program type of interest, that asked the following questions:

(1) Are there large-scale spatially explicit plans that are being used to guide mitigation or restoration?

(2) Has large-scale planning provided any benefits (e.g., environmental or reduced permitting time)?

(3) What limitations and challenges are faced in attempts to incorporate large-scale planning in mitigation or restoration?

(4) What opportunities are there for large-scale planning to be used to increase environmental uplift or predictability for project proponents?

These questionnaires were sent to a diverse set of experts, including those from resource and permitting agencies, non-governmental organizations, mitigation providers, and private industry. These experts were identified through interviews with a handful of well-networked experts: one from the U.S. Department of Agriculture, one from the U.S. Army Corps of Engineers, one from the private sector, and one from an environmental NGO . An example questionnaire and the list of experts who responded can be found below. Although the questionnaire elicited valuable information about the use of large-scale planning, several challenges necessitated a course adjustment. First, little information about how large-scale planning might change environmental outcomes or permitting times was found, in part because neither the outcomes nor times are tracked and because many of the mitigation initiatives are new. Second, large-scale plans are being developed and used in a wide variety of ways that were not yet very clearly described.

Next, additional experts with substantial knowledge about specific applications of large-scale planning were identified, and they were sent a new questionnaire that asked the following questions:

(1) Are the plans informing where to avoid impacts as well as where to position mitigation sites?

(2) With what type of compensatory mitigation mechanism are they being used (e.g., in-lieu fee versus banks)?

(3) Which types of data and ecosystem services were considered in developing these plans?

(4) Are there efforts to promote co-benefits or bundle benefits across regulatory requirements?

Each expert was also asked whether there was any evidence of increased regulatory certainty, reduced permitting time, improved environmental outcomes, or unintended negative consequences. Sample interview questions can be found below. As additional experts were identified, they were interviewed. Interview responses were supplemented with publicly available plan and program information. All the experts interviewed are identified in this appendix.

Initial Questionnaire

The initial questionnaire was sent to 32 experts. Questions were tailored to each expert's area of knowledge. For example, experts in the field of wetland and stream mitigation were asked the following questions:

(1) Are there examples of landscape-scale plans that are being used to guide wetland and stream mitigation programs and projects? Which ones do you consider effective and truly apply landscape-scale planning in implementation? For what types of mitigation are they being used (e.g., permittee-responsible mitigation, in-lieu fees, banks, advanced mitigation, large-impact sites, and so on)?

(2) Although there may be variation among the examples you note above, can you identify benefits that landscape-scale planning has provided? Where possible, please provide specific information (e.g., reduced permitting review time by an average of 30 days).

   a. Improving environmental outcomes?

   b. Greater predictability for project proponents (i.e., priority areas for avoidance)?

   c. Reducing permitting and review time for projects?

   d. Improving certainty and reducing permitting time for compensatory mitigation projects?

   e. Other?

(3) What limitations and challenges have you seen in the various attempts to incorporate landscape-scale planning into mitigation decision making so far? Do you think any of these are fundamentally unresolvable issues?

(4) Do you think there are opportunities and potential for landscape-scale planning in wetland and stream mitigation programs to be used more or in different ways to better achieve environmental uplift, greater predictability for project proponents, and more efficient project review? If so, can you describe this?

   a. Environmental outcomes?

   b. Greater predictability for project proponents (i.e., priority areas for avoidance)?

   c. Reduced permitting and review time for projects?

   d. Increased certainty and reduced permitting time for mitigation projects?

The second stage of our research involved followup interviews with experts on particular plans and programs. Questions that were asked of the experts included the following:

(1) Is the landscape-scale plan being used to inform where to avoid impacts as well as where to position offsets?

(2) With what type of program design is the landscape-scale planning being used (e.g., in-lieu fees versus banks)?

(3) What types of data and ecosystem services were considered in developing these plans?

(4) Are there any efforts to encourage co-benefits or bundle benefits across regulatory requirements?

Survey Participants

The following individuals responded to written questionnaires or participated in phone interviews:

Name	Affiliation	Questionnaire	Interview
Julia Bond	The Freshwater Trust		✓
Pieter Booth	Exponent		✓
Jae Chung	U.S. Army Corps of Engineers	✓	
Matthew Espie	Washington D.C. Department of Energy & Environment		✓
Chad Evenhouse	RES		✓
Karen Gaffney	Sonoma County Agricultural Preservation & Open Space District		✓
Christopher Galik	North Carolina State University		✓
Shauna Ginger	U.S. Fish and Wildlife Service	✓	
Galon Hall	U.S. Department of Agriculture	✓	
Abby Halperin	Pacific Forest Trust	✓	
Chris Hartley	U.S. Department of Agriculture		✓
Travis Hemmen	Westervelt Ecological Services		✓
Karen Herrington	U.S. Fish and Wildlife Service		✓
Dan Kaiser	Environmental Defense Fund		✓
George Kelly	RES		✓
Amy Kessler	Climate Action Reserve		✓
Jim Klang	Kieser & Associates		✓
Michele Laur	U.S. Department of Agriculture (NRCS)		✓
Becca Madsen	Electric Power Research Institute	✓	
Steve Martin	U.S. Army Corps of Engineers	✓	✓
Kelly Neff	Maryland Department of Environment	✓	✓
John Nickerson	Climate Action Reserve	✓	✓
Susan Payne	Maryland Department of Agriculture	✓	✓
Joshua Rogers	City of Chattanooga		✓
Julianne Schwarzer	U.S. Department of Transportation	✓	
Mindy Selman	U.S. Department of Agriculture		✓
Ted Toombs	Environmental Defense Fund		✓
Jessica Wilkinson	The Nature Conservancy		✓
David Wolfe	Environmental Defense Fund	✓	✓

APPENDIX B: DETAILED PROGRAM DESCRIPTIONS

Detailed Wetland and Stream Mitigation Programs

Virginia Aquatic Resource Trust Fund

Virginia's ILF program has been operated by TNC in its current capacity since 2011 ("Virginia Aquatic Resources Trust Fund Program Instrument," n.d.). TNC establishes priority areas for state and federal (404) wetland mitigation through the use of ecoregional assessments. "An ecoregion is a large area of land or water that contains a geographically distinct assemblage of ecosystems and natural communities, and is differentiated by climate, subsurface geology, physiography, hydrology, soils, and vegetation" (The Nature Conservancy 2009). On the basis of assessments of a number of criteria relating to water quality, habitat, species, development risk, and ecoregion conservation goals, TNC establishes maps of priority conservation areas to which funds can be applied (The Nature Conservancy 2009).

North Carolina Ecosystem Enhancement Program

The North Carolina Division of Mitigation Services (DMS) has developed river basin restoration priorities for each of the state's major river basins. Within each basin, DMS has identified targeted local watersheds (at the HUC-14 scale) to which ILF funds are prioritized. These local watersheds are chosen on the basis of habitat and water qualities criteria as well as input from local stakeholders (North Carolina Department of Environmental Quality 2016). The program was developed to facilitate NC DOT projects, although private developers can also use the ILF program where mitigation banks are not available.

King County, Washington, Mitigation Reserves Program

Home to Seattle, King County, Washington, developed an ILF program in 2011. The program is designed to, among other goals, "develop an ecologically-based site selection process to identify the most appropriate offsite mitigation options that result in greater ecological benefit to a subbasin, basin, or watershed within King County than could be achieved through on-site mitigation options that are impracticable or of low ecological value." As a part of this process, King County identified a "roster" of potential mitigation sites on the basis of its hydrologic and habitat characteristics. Mitigation sites are then selected in consultation with other watershed characteristics and plans, such as salmon conservation plans, flood hazard management plans, or greenprint maps. Roster sites are published as maps for each subwatershed. As of publication of the program instrument, all sites on the roster were owned by King County, although that is not a necessary condition for mitigation (Murphy and Greve 2011).

Maryland Watershed Resources Registry

The Maryland Watersher Resources Registry (WRR) is a mapping tool that highlights landscape-scale opportunities for projects that can drive improvements in wetland habitat, water quality, or stormwater management. The tool is shared by multiple agencies and organizations in the state but is not required in any program. "The greatest value in the WRR model is that it shows where multiple ecological benefits might be found. Sites have been evaluated in a way that maximizes the ecological benefits for the entire watershed. Moreover, rather than selecting sites simply based on a single purpose or single agency's need, a selected area can now fulfill multiple beneficial

watershed needs and regulatory requirements for a number of agencies at the same time" (Bryson et al. 2010). Specifically the tool considers impaired water status, existing conservation areas, Maryland greenprint targeted ecological areas, and connectivity across high-priority habitat areas.

Though a number of stakeholder agencies were involved in the tool's development, including the Corps, EPA, the State Highway Administration, and several state agencies, current implementation of the tool has been piecemeal. A number of permittees use the WRR as an initial site-search tool in identifying potential sites for PRM. There is no official process to require permittees to use the system; however, because many of the appropriate agencies were involved in the tool's design, permittees can have a level of certainty that regions chosen on the basis of the WRR will be looked on favorably (Kelly Neff, personal comm., 5/23). Maryland currently lacks a federally approved ILF program for wetland (404) mitigation. However, the current proposal has the WRR playing a major role in the CPF for site prioritization (Kelly Neff, pers. comm., 5/23; Maryland Department of the Environment 2015b).

Duck-Pensaukee Watershed Approach

TNC and the Environmental Law Institute developed this watershed plan as a pilot study for wetlands mitigation in Wisconsin. It is focused on identifying for preservation or restoration those wetlands that provide multiple services. To do so it considers such factors as flood abatement, water quality, carbon storage potential, coastal erosion, upland-wetland connectivity, rare species, and the Wisconsin Wildlife Action Plan high-priority sites. Watershed maps based on individual services as well as comprehensive maps are available online.[17]

The plan has potential for use in all aspects of wetland mitigation, including voluntary mitigation, PRM, or mitigation banks. The Wisconsin Wetland Conservation Trust (ILF program) highlights the Duck-Pensaukee Watershed Approach as an Advanced Watershed Plan that should be followed in prioritizing site selection where it exists (Wisconsin Department of Natural Resources 2014). The approach was approved in 2014, but its 2015 fiscal year report indicated that no mitigation projects had yet been developed (Wisconsin Department of Natural Resources 2015).

Puget Sound Characterization Framework

The Puget Sound Characterization Framework is a map-based decision-support tool to help local governments, NGOs, and private developers plan for and mitigate watershed impacts. It is designed to help planners target areas for protection, restoration, conservation, or development on the basis of hydrologic and ecological conditions. It is expressly designed to help answer "where on the landscape should management efforts be focused" and "what types of activities or actions are most appropriate to that place" (Stanley et al. 2015). Regions are primarily assessed for water flow, water quality, and fish and wildlife habitat.

Virginia Southern Watershed Area Management Plan

The Virginia Southern Watershed Area Management Plan (SWAMP) is a collaborative approach to develop strategic wildlife corridors and improve water quality. The plan laid out several conservation scenarios aimed at connecting existing conserved areas primarily through wetland

[17] http://maps.tnc.org/duckpentool/.

restoration and preservation in key "focus areas" (Erdle et al. 2001; LandMark Design Group, Inc. 2001). It has been used by local municipalities, such as Virginia Beach and Chesapeake, to develop their comprehensive city plans and to identify priority areas for wetland mitigation (Environmental Law Institute and The Nature Conservancy 2014). In-lieu fee programs and mitigation banks have also contributed to implementing the plan through mitigation site selection. There is no explicit directive or policy to encourage these programs and banks to contribute; however, they likely find that doing so generates goodwill among state and federal agencies (Steve Martin, pers. comm., 5/17). TNC and ELI report that as of 2010, more than 40,000 acres had been restored or preserved, 15% of which was the result of compensatory mitigation (Environmental Law Institute and The Nature Conservancy 2014).

Special Area Management Plans

Special area management plans (SAMPs) are a programmatic approach by the Corps to balance development with the conservation of species and aquatic resources in areas of special concern (Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix 2014). The SAMPs are often used to identify habitat corridors or restore connectivity among aquatic systems on the basis of predicted development impacts (Steve Martin, pers. comm., 5/17; Camacho et al. 2016). "The SAMP should not be considered as a super permit that accelerates development in the watersheds, but it does give greater clarity and predictability to conservation priorities and development processes" (Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix 2014). SAMPs can help funnel development projects to low-priority ecological areas by enabling expedited permits (Jae Chung, pers. comm.). Regional development permits, when developed in conjunction with SAMPs, can require that mitigation be performed on the basis of the SAMP (for example, see U.S. Army Corps of Engineers, Los Angeles District 2012), which in most cases is the responsibility of the permittee (Jae Chung, pers. comm.). See Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix (2014) for a number of examples of SAMPs as used to develop transportation projects.

California Regional Advance Mitigation Planning

The Regional Advance Mitigation Planning (RAMP) effort in California was implemented to expedite transportation projects and other infrastructure projects by predicting mitigation needs and identifying cost-effective mitigation sites that yield significant statewide benefits (Huber et al. 2009). Under the RAMP Framework, planners, in consultation with relevant state agencies and other stakeholders, develop a regional conservation assessment or "greenprint" identifying regional conservation priorities. These greenprints can then be used to identify specific potential cost-effective mitigation sites in response to major California Department of Transportation projects (Huber et al. 2009; Thorne et al. 2009). RAMPs integration into mitigation planning is being pilot tested. The framework is designed to identify economically efficient opportunities for mitigating transportation projects in advance, while also meeting other state habitat and watershed objectives, thus optimizing the use of mitigation funds (Regional Advance Mitigation Planning Work Group 2012).

Detailed Species Mitigation Programs

Midwest Wind Energy Multi-Species Habitat Conservation Plan

The Midwest Wind Energy Multi-Species Habitat Conservation Plan (MSHCP) was developed to facilitate wind energy production across eight states in the upper Midwest. It is expected to be finalized in late 2017. The MSHCP covers seven species, five of which are listed as either endangered or threatened under the ESA. The sixth species, the bald eagle, is protected under the Bald and Golden Eagle Protection Act, and the seventh species, the little brown bat, is under review for listing on ESA (U.S. Fish and Wildlife Service 2016). The trade industry group, American Wind Energy Association, is designated as the master permittee and helps to facilitate compliance by individual wind energy companies, "providing the industry with predictability, an efficient permit review process, and allowing for consideration of impacts and compensatory measures on a landscape scale" (Mead and Wilkinson 2015).

The plan excludes some key habitat areas from its coverage, thus encouraging developers to avoid those areas by allowing only take authorizations within "covered lands."[18] The plan also details mitigation expectations for any permitted take authorizations, which include the option to use an in-lieu fee program or mitigation bank where available.[19] Both preservation of existing habitat and restoration of potential habitat are allowable mitigation methods under the plan. Sites chosen for mitigation must meet species-specific criteria, often including proximity to occupied habitat or breeding areas. Given the overlap of some species within the coverage area, stacking of habitat is allowed under the plan, although at a reduced crediting rate (U.S. Fish and Wildlife Service 2016).

Columbia Pipeline Group MSHCP

The Columbia Pipeline Group (CPG, formerly NiSource) MSHCP covers incidental take authorizations of 10 listed species across 14 states that result from the operation, maintenance, and expansion of the company's natural gas pipeline network. The area covered by the HCP predominantly surrounds existing pipeline; although the plan outlines specific measures to avoid individual species take, it precludes no areas for development ("NiSource Multi-Species Habitat Conservation Plan" 2013). The HCP has significantly reduced the time required for project review compared with the time that would have been required under Section 7 consultation (Mead and Wilkinson 2015).

CPG is solely responsible for mitigation, but it can use mitigation banks where available, or it can contribute to a National Fish and Wildlife Foundation Mitigation Fund to achieve compliance ("NiSource Multi-Species Habitat Conservation Plan" 2013). As part of the mitigation requirements of the HCP, the non-profit The Conservation Fund has developed a system of decision tools and green infrastructure maps to guide selection of mitigation projects "to meet the requirements of the MSHCP that also advanced other conservation objectives" such as wetland areas and connected habitats (The Conservation Fund 2011). The use of this tool is not required under the HCP; however, the Mitigation Panel that oversees the Mitigation Fund is expected to

[18] Examples of areas not considered covered lands include land within three miles of the Great Lakes and within specific bird migratory areas (U.S. Fish and Wildlife Service 2016).

[19] The plan provides a mechanism for the development of mitigation-implementing entities (MIEs), which manage and seek approval for mitigation sites funded through a development fee (U.S. Fish and Wildlife Service 2016).

utilize the tool. Additionally, FWS expects CPG to at least score projects using the tool for any PRM (Karen Herrington, pers. comm., 6/30).

The CPG MSHCP was approved in 2013, but it has implemented no mitigation projects. FWS expects formal proposals for such projects, which will likely be implemented by CPG by the end of 2016 (Karen Herrington, pers. comm., 6/30).

Pima County MSCP

The Pima County Multi-Species Conservation Plan (MSCP) is designed to facilitate sustainable development within Pima County, Arizona. The plan covers 44 species, 10 of which are federally listed. As the permittee, Pima County is responsible for taking action to avoid impacts to species that result from both county and private development and for mitigating any incidental take. The county utilizes a Conservation Lands System map to prioritize potential sites for development and conservation. This tool was developed in conjunction with the Sonoran Desert Conservation Plan, which enabled the use of "voter-approved bond funding to acquire open-space properties that conserve many species and their habitats, sustain ecosystem functions, protect cultural resources, and support the continuation of cattle ranching" (Pima County Office of Sustainability and Conservation 2012). Under both the SDCP and the MSCP, mitigation is undertaken entirely by the county. The location of impact dictates the mitigation ratio used; priority mitigation lands have a much higher mitigation ratio than other mitigation lands, thus discouraging development there. The MSCP allows for stacking of wetland (404) and species mitigation credits; county-owned lands used for 404 mitigation can also generate MSCP credits, but only to the extent of the quality of the habitat as it existed prior to 404 restoration ("Pima County's Multi-Species Conservation Plan: Final," n.d.).

Western Riverside County MSHCP

The Western Riverside County MSHCP was developed to facilitate development and mitigation around the take of 146 species in California. The plan established a 500,000-acre conservation goal for the protection and management of these species, which requires acquisition of more than 150,000 additional acres not already managed, while streamlining the permit review process for developers and infrastructure projects. The conservation reserve goal is split between federal, state, local, and private landholders (Ouellette and Landry 2015). Although the specific location of all 500,000 acres is not indicated, the plan designates larger "criteria areas" within which land is prioritized for acquisition. Development within this criteria area has more stringent mitigation requirements than development outside of it (Western Riverside County Regional Conservation Authority 2003). The implementation of the plan has greatly expedited infrastructure and development project review (Ouellette and Landry 2015).

The MSHCP incentivizes development in some areas through an agency review process. "If the reviewing municipality determines that any of the subject property is necessary for conservation, the [Regional Conservation Authority] negotiates with the landowner for acquisition and potential development incentives" (Ouellette and Landry 2015). Local development fees help fund mitigation acquisition; landowners who meet certain criteria consistent with the HCP can also offer up their properties for sale. Developers are also able to offset their fees through conservation banks where they exist (Ouellette and Landry 2015).

East Contra Costa County HCP

The East Contra Costa County HCP is intended to facilitate development across several municipalities in eastern Contra Costa County, California, while enabling the take of 28 covered species. The HCP set a goal of developing a preserve system of 23,800 to 30,300 acres to offset expected growth. As part of the preserve system, plan area was divided into six regions, each with individual acquisition priorities for achieving the plan goals. Additionally, the permit area for the plan discourages development in key habitat areas by not allowing for incidental take from covered activities in those areas. The HCP also varies developer fees, depending on the land use; these fees are one source of funding utilized by the HCP to acquire and manage lands for the preserve. The HCP is also designed to provide a mechanism to facilitate wetland mitigation (Jones & Stokes 2006).

Iron County HCP

The Iron County HCP was established in Utah in 1998 and has since been updated. The HCP covers the federally threatened Utah prairie dog from residential and commercial development throughout the county. The primary method of mitigation is translocation of colonies to federal lands, but payment of a compensatory mitigation fee of $1,000 per acre is also acceptable. The HCP established "red" and "green" development zones on the basis of existing development patterns. Development in red zones, which tend to be more rural, requires more extensive mitigation (including higher fees) than green zones or the use of approved conservation banks (Iron County Commission 2013). At least two conservation banks actively a habitat credit exchange program serve the area (U.S. Fish and Wildlife Service 2012).[20]

Lesser Prairie Chicken

The Lesser Prairie Chicken Range-wide Conservation Plan (RWP) was a coordinated effort by five states to conserve the Lesser Prairie Chicken (LPC) in the face of expanding energy development. When the RWP was initiated, the LPC had been precluded from listing. To avoid the need for listing, the plan attempted to proactively conserve habitat through voluntary enrollment by developers (Van Pelt et al. 2013). In 2014, USFWS officially listed the LPC as threatened, but under Section 4(d) the RWP acts as a framework for enabling incidental take (Van Pelt et al. 2015).

The RWP establishes mitigation fee requirements for any development that results in unavoidable impacts to the LPC. Developers are encouraged to avoid key focal areas, where mitigation fees are higher than in other areas covered by the HCP. The Crucial Habitat Assessment Tool (CHAT), a mapping tool, is available to help guide developers away from priority areas, while also identifying priority areas for mitigation.[21] Through the use of this tool, the Western Associate of Fish and Wildlife Agencies (WAFWA) has seen an increase in overlapping and clustering of oil and gas development, while unavoidable impacts have resulted in planned mitigation activities across approximately 96,000 acres (Van Pelt et al. 2015).

[20] The Panoramaland Resource Conservation & Development Council operates the Utah Prairie Dog Habitat Credits Exchange. More information can be found at http://panoramalandrcd.org/utah-prairie-dog-habitat-credits-exchange-program/.
[21] Available at http://kars.ku.edu/maps/sgpchat/.

Greater Sage-grouse

The Greater Sage-grouse was proposed as a candidate for listing several times throughout the 2000s. In 2010, FWS developed a multi-state conservation strategy to prepare for the bird's listing as well as to provide a mechanism for mitigating impacts on Bureau of Land Management (BLM) lands. As part of this strategy, it recommended identifying priority areas for conservation and requiring compensatory mitigation for impacts to those areas (U.S. Fish and Wildlife Service 2014). Ultimately, in response to efforts to maintain and expand existing sage-grouse populations, FWS decided in 2015 that listing of the bird on the ESA was not warranted (80 FR 59857).
A number of states have begun to design programs to incorporate the FWS strategy so as to maintain the "not warranted" finding. Nevada is developing a greater sage-grouse credit exchange program to enable landowners to generate conservation credits that can be sold to mitigate impacts on BLM or USFS land (Copeland et al. 2014). Crediting ratios are predicated on habitat quality and proximity of impact and offset sites. Connectivity of mitigation sites is not stressed beyond a focus on mapped priority habitat management areas (Nevada Sagebrush Ecosystem Council 2016). A forthcoming strategic action plan "will identify prioritized areas on public and private lands to implement a landscape scale restoration effort…The prioritization will include efforts to use mitigation funding in areas where sage-grouse will derive the most benefit, even if those areas are not adjacent to or in the vicinity of impacted populations" (Copeland et al. 2014).

As one example of permittee-responsible mitigation, the Oregon Department of Fish and Wildlife has developed mitigation guidelines for development that is covered by county, state, and federal permits on public land and affects sage-grouse habitat (Oregon Department of Fish and Wildlife 2015). These requirements highlight the need to avoid impacts in core area habitats and a preference for mitigation in these same areas when it is required. Habitat connectivity is considered in defining these core areas, and mitigation is preferred in areas with existing conservation efforts (Oregon Department of Fish and Wildlife 2012; Sage-Grouse Conservation Partnership 2015). The state provides maps of core habitat areas and a framework for site selection. The framework also includes an assessment of other criteria such as risk of wildlife and invasive species (Sage-Grouse Conservation Partnership 2015).

Detailed Water Management Programs

Maryland Nutrient Trading Program

The Maryland Nutrient Trading Program was designed to offset new or expanded nutrient loads to the Chesapeake Bay through the use of agricultural offsets. As of July 2016, no trades had been transacted through the program (Susan Payne, pers. comm., 7/13). However, Maryland has plans to add carbon credits to relevant agricultural BMPs to make progress toward its GHG reduction requirements under the 2009 Greenhouse Gas Reduction Act (Maryland Department of the Environment 2015a). The timeline for implementation is uncertain due to the lack of a robust carbon market in Maryland (Susan Payne, pers. comm., 7/13).

Oregon Temperature Trading

Several municipalities and utilities in Oregon have developed, or are developing, programs to purchase temperature credits to help meet TMDL temperature requirements. These programs are especially common in the Pacific Northwest, where temperature-dependent salmon spawn (Guillozet 2015). For example, discharges from the Water Reclamation Facility for Medford,

Oregon, raise the temperature of the Rogue River above allowable standards. Instead of installing expensive chillers or other equipment, the city purchases credits, which are generated by landowners along the Rogue River who plant trees to generate shade credits. The tree planting also provides habitat and reduces sediment, nitrogen, and phosphorous (Oregon Department of Environmental Quality, n.d.). The Freshwater Trust, which manages the generation of credits on private lands, prioritizes potential sites on the basis of a watershed model. This model identifies potential thermal benefits from tree planting, but also opportunities to promote salmonid spawning habitat restoration and to contribute to FWS species recovery plans (Julia Bond, pers. comm., 8/17). A similar program in Oregon's Tualatin Basin has found success by working alongside the Conservation Reserve Enhancement Program to optimize the outcomes of both programs (Cochran and Logue 2011). Because meeting temperature loading is their primary goal, these programs primarily utilize a bottom-up site selection approach to prioritizing the best credit-generating sites (Guillozet 2015).

Washington, D.C., Stormwater Retention Credit Trading Program

The District Department of Energy and Environment established a stormwater credit trading program in 2013. New construction or major renovations on land greater than 5,000 square feet must retain onsite rainfall equal to a 90th percentile storm event (~1.2 inch). The new program allows permittees to achieve as much as 50% of the required retention off site through the purchase of stormwater retention credits (SRCs). SRCs can be generated by installing stormwater BMPs on unregulated sites or by allowing permittees that exceed the required retention on their site to generate credits. Permittees also have an option of paying an in-lieu fee, which is typically more expensive than obtaining SRCs (Van Wye 2012; Center for Watershed Protection 2013).

Chattanooga, Tenneesee, Water Quality Program

Chattanooga has developed stormwater management guidelines as a condition of its stormwater NPDES permit. New development and re-development projects must meet specified "stay on volume" (SOV) requirements for stormwater retention (between 0.5and 1.6 inches). Voluntary projects or projects that exceed SOV requirements can earn transferrable "credit coupons." New development sites may utilize credit coupons to achieve SOV only if they can demonstrate hardship, which is typically granted when hydrologic or soil conditions make stormwater BMPs impractical. The one exception to this rule is in the South Chickamauga Creek Watershed, which has stricter SOV requirements; a portion of the SOV (corresponding to the additional stringency of the requirements) may always be met using credit coupons (City of Chattanooga 2014). As of June 2016, no credit coupons had been generated (Joshua Rogers, pers. comm., 7/1/16). As an alternative to using credit coupons, developers may also pay an in-lieu fee to the city or perform offsite mitigation within the same watershed (City of Chattanooga 2014).

Detailed GHG Mitigation Programs

Oregon Carbon Dioxide Standard

The Oregon Carbon Dioxide Standard was passed in 1997 to require new power plants to emit carbon dioxide at a rate 17% lower than existing rates. Plants have the option of utilizing offset projects or paying a fee in lieu of adopting emissions-reducing technology. As of 2014, all facilities had utilized the fee option to comply. The nonprofit The Climate Trust is tasked with managing

these funds through the purchase and development of carbon reduction projects or offsets. The Climate Trust seeks a diverse mix of cost-effective offset projects, with a preference for those that utilize third-party standards and those located within Oregon. The Climate Trust recognizes that offset projects can bring additional environmental benefits, but GHG reductions are the principle objective (The Climate Trust 2014).

California Cap-and-Trade Program (Assembly Bill 32)

Assembly Bill 32 (AB 32), the Global Warming Solutions Act, was passed in California in 2006. It required the state to develop a plan to limit its GHG emissions. The California Air Resources Board (ARB) ultimately designed a statewide cap-and-trade program in 2010 to help meet this goal. Under the program, regulated entities such as electric generating utilities and large industrial facilities must obtain allowances for their GHG emissions. Entities may also purchase offsets for up to 8% of their emissions (California Air Resources Board 2014).

Regional Greenhouse Gas Initiative

The Regional Greenhouse Gas Initiative (RGGI) is a cap-and-trade initiative developed by a consortium of nine northeastern states: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont. Power plants in those states must obtain allowances for their carbon dioxide emissions, predominantly through state auctions. The total available allowances, or cap, will decrease by 2.5% each year through 2020 (Ramseur 2014). Each state has the flexibility to choose how to use auction revenues raised through RGGI. As of 2013, approximately 50% of auction proceeds were used for energy efficiency or renewable energy programs (Ramseur 2014).

Detailed Natural Resource Damage Assessments

Deepwater Horizon Oil Spill

Following the *Deepwater Horizon* oil spill of 2010, a nine-member trustee council was established to assess damages and manage the remediation efforts under the OPA. The Final Programmatic Damage Assessment and Restoration Plan was released in 2016. It details how damage settlement funds will be utilized to restore the Gulf of Mexico in response to the spill (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). Given the extensive scale of the damages, the trustees developed an integrated ecosystem restoration plan and governance structure to achieve five goals: (1) restore and conserve habitat, (2) restore water quality, (3) replenish and protect living coastal and marine resources, (4) provide and enhance recreational opportunities, and (5) provide for monitoring, adaptive management, and administrative oversight. Funds will be allocated by eight regional trustee implementation groups (TIGs) to a portfolio of restoration projects to optimize the benefits in pursuit of the five goals (Deepwater Horizon Natural Resource Damage Assessment Trustees 2016). Restoration projects and plans are being developed by the TIGs, and the first projects are expected to be implemented in April 2017 (Michele Laur, pers. comm., 8/10).[22]

[22] BP provided advance restoration funding of $1 billion prior to the development of the Final Programmatic Damage Assessment and Restoration Plan. The Department of Justice reached an $8.1 billion settlement with BP in April 2016. The remaining $7.1 billion will be allocated through the TIGs over a 15-year period (Michele Laur, pers. comm., 8/10).

REFERENCES

Arbuckle, J. Gordon. 2013. "Clean Water State Revolving Fund Loans and Landowner Investments in Agricultural Best Management Practices in Iowa." *JAWRA Journal of the American Water Resources Association* 49 (1): 67–75. doi:10.1111/j.1752-1688.2012.00688.x.

Baldino, Chelsea, Lydia P. Olander, and Christopher S. Galik. 2016. "Assessing County and Regional Habitat Conservation Plan Creation." NI WP 16-05. Durham, North Carolina: Nicholas Institute, Duke University. https://nicholasinstitute.duke.edu/environment/publications/assessing-county-and-regional-habitat-conservation-plan-creation-what-contributes.

Barbour, Elisa, and Elizabeth A. Deakin. 2012. "Smart Growth Planning for Climate Protection: Evaluating California's Senate Bill 375." *Journal of the American Planning Association* 78 (1): 70–86.

Bergstein, Shira A., and April Mo. 2012. "The Role of Habitat Conservation Plans in Facilitating Transportation Infrastructure: A Preliminary Investigation and Proposal for Further Research." UCTC-FR-2012-02. University of California Transportation Center.

Brander, Luke M., Raymond J.G.M. Florax, and Jan E. Vermaat. 2006. "The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature." *Environmental and Resource Economics* 33 (2): 223–50. doi:10.1007/s10640-005-3104-4.

Brown, Janice W. 2006. "Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects." Cambridge, Massachusetts: U.S. Department of Transportation.

Bryson, E., R. Spagnolo, M. Hoffmann, and W. Seib. 2010. "Achieving Ecosystem Health Using a Watershed Approach: The Watershed Resources Registry Pilot Project in Southwestern Maryland." *National Wetlands Newsletter* 32 (3): 8–11.

California Air Pollution Control Officers Association. 2015. "Greenhouse Gas Reduction Exchange Administrative Guidelines." Version 2. http://www.capcoa.org/.

California Air Resources Board. 2014. "First Update to the Climate Change Scoping Plan." Sacramento, California. https://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.

———. 2016. "Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds." Sacramento, California. http://arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2016_final.pdf.

Camacho, Alejandro E., Elizabeth M. Taylor, and Melissa L. Kelly. 2016. "Lessons from Area-Wide, Multi-Agency Habitat Conservation Plans in California." *Environmental Law Reporter* 46 (3): 10222–10248.

Camacho, Alejandro E., Elizabeth M. Taylor, Melissa L. Kelly, and Stephanie L. Talavera. 2016. "Improving Emerging Regulatory Experiments in Permit Process Coordination for Endangered Species and Aquatic Resources in California." *Environmental Law Reporter* 46 (2): 10131–40.

Center for Watershed Protection. 2013. "Stormwater Management Guidebook." Ellicott City, Maryland: Prepared for District Department of the Environment Watershed Protection Division. http://doee.dc.gov/sites/default/files/dc/sites/ddoe/page_content/attachments/FinalGuidebook_changes%20accepted_Chapters%201-7_07_29_2013_compressed.pdf.

Chan, Kai MA, M. Rebecca Shaw, David R. Cameron, Emma C. Underwood, and Gretchen C. Daily. 2006. "Conservation Planning for Ecosystem Services." *PLoS Biol* 4 (11): e379.

City of Chattanooga. 2014. "Water Quality Program Credits and Incentives Manual." http://www.chattanooga.gov/images/citymedia/publicworks/Credits__Incentives_Manual.pdf.

Cochran, Bobby, and Charles Logue. 2011. "A Watershed Approach to Improve Water Quality: Case Study of Clean Water Services' Tualatin River Program." *Journal of the American Water Resources Association* 47 (1): 29–38.

Council on Environmental Quality. 2016. Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews. Memorandum from Executive Office of the President. https://www.energy.gov/nepa/downloads/guidance-consideration-greenhouse-gas-emissions-and-effects-climate-change-national.

Copeland, John, Melissa Faigeles, Kelly McGowan, and Lara Niell. 2014. "2014 Nevada Greater Sage-Grouse Conservation Plan." Carson City, Nevada: Sagebrush Ecosystem Council.

Curran, Marissa L. 2015. "The Wildlife Wildcard: Natural Resource Damages and Putting a Price on Nature." *Natural Resources & Environment* 30 (2): 5.

Deal, Robert L., Bobby Cochran, and Gina LaRocco. 2012. "Bundling of Ecosystem Services to Increase Forestland Value and Enhance Sustainable Forest Management." *Forest Policy and Economics* 17 (April): 69–76. doi:10.1016/j.forpol.2011.12.007.

Deepwater Horizon Natural Resource Damage Assessment Trustees. 2016. "Plan for Deepwater Horizon Oil Spill Natural Resource Injury Restoration: An Overview." http://www.gulfspillrestoration.noaa.gov/sites/default/files/wp-content/uploads/Overview_04-07-16_final-508.pdf.

DeMeester, Julie, and Sarah Adair. 2015. "EPA's Clean Power Plan: Understanding and Evaluating the Proposed Federal Plan and Model Rules." *Environmental Law Reporter* 45: 11155–63.

Donlan, C. Josh, Todd Gartner, Timothy Male, and Ya-Wei Li. 2013. "Species Conservation Incentives." *Environmental Policy and Law* 43 (3): 162–66.

Environmental Law Institute and The Nature Conservancy. 2014. "Watershed Approach Handbook: Improving Outcomes and Increasing Benefits Associated with Wetland and Stream Restoration and Protection Projects." Washington, D.C. http://www.eli.org/research-report/watershed-approach-handbook.

Erdle, Sandra Y., Joseph T. Weber, Richard K. Myers, and Steven H. Carter-Lovejoy. 2001. Conservation Plan for the Southern Watershed Area. Natural Heritage Technical Report #00-12. Richmond, Virginia: Virginia Department of Conservation and Recreation, Division of Natural Heritage. https://www.vbgov.com/government/departments/planning/areaplans/Documents/Pungo-Blackwater-RuralArea/consplanrpt.pdf.

Executive Office of the President. 2015. "Mitigating Impacts on Natural Resources from Development and Encouraging Related Private Investment." Memorandum 80 FR 68743. https://federalregister.gov/a/2015-28466.

Faeth, Paul. 2000. "Fretile Ground: Nutrient Trading's Potential to Cost Effectively Improve Water Quality." Washington, D.C.: World Resources Institute. http://pdf.wri.org/fertile_ground.pdf.

Fitzgerald, Joan, and Joshua Laufer. 2017. "Governing Green Stormwater Infrastructure: The Philadelphia Experience." Local Environment: The International Journal of Justice and Sustainability 22(2): 256–268. http://dx.doi.org/10.1080/13549839.2016.1191063.

Galik, Christopher S., Brian C. Murray, and D. Evan Mercer. 2013. "Where Is the Carbon? Carbon Sequestration Potential from Private Forestland in the Southern United States." *Journal of Forestry* 111 (1): 17–25.

Gasper, Rebecca R., Mindy Selman, and Matthias Ruth. 2012. "Climate Co-Benefits of Water Quality Trading in the Chesapeake Bay Watershed." *Water Policy* 14 (5): 758–765.

Greenway, Greg. 2010. "Getting the Green Light for Senate Bill 375: Public Engagement for Climate-Friendly Land Use in California." *Pepperdine Dispute Resolution Law Journal* 10 (3): 433.

Guillozet, Kathleen. 2015. "Shade Trading: An Emerging Riparian Forest-Based Payment for Ecosystem Services Market in Oregon, USA." *Environmental Management* 56 (4): 957–970.

Haines, Andy, Anthony J. McMichael, Kirk R. Smith, Ian Roberts, James Woodcock, Anil Markandya, Ben G. Armstrong, et al. 2010. "Public Health Benefits of Strategies to Reduce Greenhouse-Gas Emissions: Overview and Implications for Policy Makers." *The Lancet* 374 (9707): 2104–2114.

Hamrick, Kelley, and Allie Goldstein. 2016. "Raising Ambition: State of the Voluntary Carbon Markets 2016." Washington, D.C.: Forest Trends. http://www.forest-trends.org/documents/files/doc_5242.pdf.

Hruby, Thomas, Kim Harper, and Stephen Stanley. 2009. "Selecting Wetland Mitigation Sites Using a Watershed Approach." #09-06-032. Olympia, Washington: Washington State Department of Ecology. https://fortress.wa.gov/ecy/publications/summarypages/0906032.html.

Huber, Patrick R., D. Richard Cameron, James H. Thorne, and Ted M. Frink. 2009. "Regional Advance Mitigation Planning: A Pilot Study Integrating Multi-Agency Mitigation Needs and Actions within a Comprehensive Ecological Framework." In Technical Paper for ICOET Conference, Duluth, MN. https://rampcalifornia.water.ca.gov/documents/18/949688/Huber_etal_ICOET_final.pdf.

Iron County Commission. 2013. "Final Low-Effect Habitat Conservation Plan for the Utah Prairie Dog in Residential and Commercial Development Areas of Iron County, Utah." https://www.fws.gov/mountain-prairie/species/mammals/utprairiedog/20131101FinalLowEffectIronCountyHCP.pdf.

Jones & Stokes. 2006. "East Contra Costa County Habitat Conservation Plan and Natural Community Conservation Plan." San Jose, California. Prepared for East Contra Costa County Habitat Conservation Plan Association. http://www.co.contra-costa.ca.us/depart/cd/water/HCP/archive/final-hcp-rev/final_hcp_nccp.html.

Kiesecker, Joseph M, Holly Copeland, Amy Pocewicz, and Bruce McKenney. 2010. "Development by Design: Blending Landscape-Level Planning with the Mitigation Hierarchy." Frontiers in Ecology and the Environment 8 (5): 261–66.

Kieser, Mark S., and Jamie L. McCarthy. 2015. "Water Quality Trading in Ohio." In Use of Economic Instruments in Water Policy: Insights from International Experience, edited by M. Lago, J. Mysiak, C.M. Gómez, G. Delacámara, and A. Maziotis. Springer. http://link.springer.com/chapter/10.1007/978-3-319-18287-2_15.

Laitos, Jan G., and Heidi Ruckriegle. 2012. "The Clean Water Act and the Challenge of Agricultural Pollution." *Vermont Law Review* 37: 1033–70.

LandMark Design Group, Inc. 2001. "Multiple Benefits Conservation Plan." Prepared for The Hampton Roads Planning District Commission. http://www.vbgov.com/government/departments/planning/areaplans/Documents/Agricultural%20and%20Rural%20Areas/SWAMP_MBCP_report.pdf.

Langpap, Christian, and Joe Kerkvliet. 2012. "Endangered Species Conservation on Private Land: Assessing the Effectiveness of Habitat Conservation Plans." *Journal of Environmental Economics and Management* 64 (1): 1–15.

Lederman, Jaimee, and Martin Wachs. 2014. "Transportation and Habitat Conservation Plans: Improving Planning and Project Delivery While Preserving Endangered Species." UCTC-FR-2014-04. University of California Transportation Center.

Livingston, Adam. 2016. "Sustainable Communities Strategies and Conservation." Sequoia Riverlands Trust. http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/california/sustainable-communities-strategies-and-conservation.pdf.

Maine Department of Environmental Protection. 2011. "State of Maine - In-lieu fee Program Instrument." Augusta, Maine. http://www.nae.usace.army.mil/Portals/74/docs/regulatory/Mitigation/ILFP_ME.pdf.

Marie Venner Consulting and URS Corporation, SEPI Engineering Group, Inc., and Parametrix. 2014. An Ecological Approach to Integrating Conservation and Highway Planning, vol. 1. SHRP 2 Report S2-C06-RW-1. Washington, D.C.: Transportation Research Board. http://www.trb.org/Main/Blurbs/169515.aspx.

Maryland Department of the Environment. 2015a. "Greenhouse Gas Emissions Reduction Act Plan Update." Baltimore, Maryland. http://www.mde.state.md.us/programs/Air/ClimateChange/Documents/ClimateUpdate2015.pdf.

———. 2015b. "Maryland In-Lieu Fee Program Prospectus." Baltimore, Maryland. http://www.nab.usace.army.mil/Portals/63/docs/Regulatory/SPN15-52%20-%20ILF%20PN.pdf.

McElfish Jr, James M., Linda Breggin, John A. Pendergrass III, and Susan Bass. 2006. "Inventing Nonpoint Controls: Methods, Metrics and Results." *Villanova Environmental Law Journal* 17: 87–216.

Mead, Deborah L., and Jessica Wilkinson. 2015. "Meeting the Promise of the Golden Age of Mitigation." Paper 6. Endangered Species Act: Current & Emerging Issues Affecting Resource Development. Rocky Mountain Mineral Law Foundation.

Merow, Cory, Mathew J. Smith, Thomas C. Edwards, Antoine Guisan, Sean M. McMahon, Signe Normand, Wilfried Thuiller, Rafael O. Wüest, Niklaus E. Zimmermann, and Jane Elith. 2014. "What Do We Gain from Simplicity versus Complexity in Species Distribution Models?" *Ecography* 37 (12): 1267–81. doi:10.1111/ecog.00845.

Murphy, Michael, and Darren Greve. 2011. "King County Mitigation Reserves Program In-lieu fee Program Instrument." Seattle, Washington: King County Department of Natural Resources and Parks. http://www.kingcounty.gov/environment/water-and-land/wetlands/mitigation-credit-program.aspx.

Murray, Brian C. 2015. "Why Have Carbon Markets Not Delivered Agricultural Emission Reductions in the United States?" *Choices* 30 (2): 1–5.

Nevada Sagebrush Ecosystem Council. 2016. "Conservation Credit System Manual." Version 1.1. South Lake Tahoe, CA. http://sagebrusheco.nv.gov/uploadedFiles/sagebrusheconvgov/content/CCS/Nevada%20Conservation%20Credit%20System%20Manual%20-%20version%201.1.pdf.

U.S.Army Corps of Engineers, New England District. 2012. "New Hampshire Aquatic Resource Mitigation Fund Final In-Lieu Fee Program Instrument." http://www.nae.usace.army.mil/Portals/74/docs/regulatory/Mitigation/NHinstrument051812.pdf.

"NiSource Multi-Species Habitat Conservation Plan." 2013. http://www.fws.gov/Midwest/endangered/permits/hcp/nisource/2013NOA/NiSourceHCPfinalJune2013.html.

North Carolina Department of Environmental Quality. 2016. "DMS Planning." Accessed May 26. https://deq.nc.gov/about/divisions/mitigation-services/dms-planning.

Oregon Department of Environmental Quality. n.d. "Medford Regional Water Reclamation Facility Thermal Credit Trading Program." http://www.deq.state.or.us/wq/trading/docs/MedfordThermalTrading.pdf.

Oregon Department of Fish and Wildlife. 2012. "Implementing Habitat Mitigation for Greater Sage-Grouse Under the Core Area Approach." http://www.dfw.state.or.us/wildlife/sagegrouse/docs/Oregon_Sage-grouse_Mitigation_Framework_3-20-12_Revision.pdf.

———. 2015. "Greater Sage-Grouse Conservation Strategy for Oregon." http://www.dfw.state.or.us/wildlife/sagegrouse/docs/OAR_140_Greater_Sage-Grouse_Cons_Strat.pdf.

Ouellette, Michelle, and Charles Landry. 2015. "The Western Riverside County Multiple Species Habitat Conservation Plan: Looking Forward after Ten Years." *Natural Resources & Environment* 29 (3): 40.

Pendleton, Linwood H., Ariana E. Sutton-Grier, David R. Gordon, Brian C. Murray, Britta E. Victor, Roger B. Griffis, Jen AV Lechuga, and Chandra Giri. 2013. "Considering 'Coastal Carbon' in Existing US Federal Statutes and Policies." *Coastal Management* 41 (5): 439–456.

Pima County. 2016. Multi-species Conservation Plan for Pima County, Arizona: Final. Submitted to the Arizona Ecological Services office of the U.S. Fish and Wildlife Service, Tucson, Arizona. https://webcms.pima.gov/UserFiles/Servers/Server_6/File/Government/Office%20of%20Sustainability%20and%20Conservation/Conservation%20Sciece/Multi-species%20Conservation%20Plan/MSCP_Final_MainDoc.pdf.

Pima County Office of Sustainability and Conservation. 2012. "Pima County's Multi-Species Conservation Plan: Balancing Development and Habitat Conservation." http://www.pima.gov/cmo/sdcp/mscp/MSCPdocs/Pima_County_MSCP_Summary.pdf.

Pollak, Daniel. 2001. "The Future of Habitat Conservation? The NCCP Experience in Southern California." https://www.library.ca.gov/crb/01/09/01-009.pdf.

Presley, Gail L. 2011. "California's Natural Community Conservation Planning Program: Saving Species Habitat amid Rising Development." In *The Endangered Species Act and Federalism: Effective Conservation through Greater State Commitment*, edited by Kaush Arha and Barton H. Thompson, 352. Washington, D.C.: RFF Press.

Qiu, Jiangxiao, and Monica G. Turner. 2013. "Spatial Interactions among Ecosystem Services in an Urbanizing Agricultural Watershed." *Proceedings of the National Academy of Sciences* 110 (29): 12149–12154.

Ramseur, Jonathan L. 2014. "The Regional Greenhouse Gas Initiative: Lessons Learned and Issues for Policymakers." Congressional Research Service, no. R41836(November). http://digital.library.unt.edu/ark:/67531/metadc491501/m1/1/high_res_d/R41836_2014Nov14.pd.

Regional Advance Mitigation Planning Work Group. 2012. "Draft Statewide Framework for Regional Advance Mitigation Planning in California." Sacramento, California: Prepared for California Department of Water Resources.

Regional Greenhouse Gas Initiative, Inc. 2015. "Investment of RGGI Proceeds through 2013." http://rggi.org/docs/ProceedsReport/Investment-RGGI-Proceeds-Through-2013.pdf.

RIBITS (Regulatory In-Lieu Fee and Bank Information Tracking System). Last accessed January 11, 2017. https://ribits.usace.army.mil/.

Ribaudo, Marc O., and Cynthia J. Nickerson. 2009. "Agriculture and Water Quality Trading: Exploring the Possibilities." *Journal of Soil and Water Conservation* 64 (1): 1–7.

Sage-Grouse Conservation Partnership. 2015. "The Oregon Sage-Grouse Action Plan." Salem, Oregon: Governor's Natural Resources Office. http://oregonexplorer.info/content/oregon-sage-grouse-action-plan?topic=203&ptopic=179.

Santa Barbara County Air Pollution Control District. 2015. "Greenhouse Gas Mitigation and CEQA: A Review of Mitigation Strategies for Projects Subject to the California Environmental Quality Act." http://www.ourair.org/wp-content/uploads/ghg-mitigation-and-ceqa.pdf.

Scarlett, Lynn. 2011. "America's Working Lands: Farm Bill Programs and Landscape-Scale Conservation." Working Paper WP11LS1. Lincoln Institute of Land Policy. http://www.lincolninst.edu/pubs/1958_America-s-Working-Lands.

Sesser, Kristin A., Matthew E. Reiter, Daniel A. Skalos, Khara M. Strum, and Catherine M. Hickey. 2016. "Waterbird Response to Management Practices in Rice Fields Intended to Reduce Greenhouse Gas Emissions." *Biological Conservation* 197: 69–79.

Sonoma County Agricultural Preservation and Open Space District. 2006. "Connecting Communities and the Land: A Long-Range Acquisition Plan." http://www.sonomaopenspace.org/wp-content/uploads/2014/09/District-Acquisition-Plan-2006.pdf.

Stanley, Stephen, Susan Grigsby, Derek Booth, David Hartley, Richard Horner, Tom Hruby, Jennifer Thomas, et al. 2015. "Puget Sound Characterization Volume 1: The Water Resources Assessments." #11-06-016. Olympia, Washington: Washington State Department of Ecology.

Stephenson, Kurt, and Leonard Shabman. 2011. "Rhetoric and Reality of Water Quality Trading and the Potential for Market-like Reform." *Journal of the American Water Resources Association* 47 (1): 15–28.

Stillwater Sciences. 2016. "Swainson's Hawk Habitat Quantification Tool, Scientific Rationale Document." Vol 3. Prepared by Stillwater Sciences, Berkeley, California for Environmental Defense Fund, Sacramento, California.

The Climate Trust. 2014. "Plowing New Pathways: Developing Quality Offsets in a Maturing Market." Portland, Oregon. https://www.climatetrust.org/wp-content/uploads/2014/11/2014-Oregon-5-Year-Report-EMAIL-141117-CAM-FNL.pdf.

The Conservation Fund. 2011. "Implementing the NiSource Multi-Species Habitat Conservation Plan." Arlington, Virginia. http://www.conservationfund.org/images/projects/files/The-Conservation-Fund-NiSource-Summary-2011.pdf.

The Nature Conservancy. 2009. "The Nature Conservancy's Watershed Approach to Compensation Planning for the Virginia Aquatic Restoration Trust Fund." http://www.nature.org/media/virginia/exhibit_a_comp_planning_framework_final.pdf.

The Nature Conservancy and Sonoma County Agricultural Preservation and Open Space District. 2016. "Conserving Landscapes, Protecting the Climate: The Climate Action through Conservation Project." San Francisco and Santa Rosa, California. http://scienceforconservation.org/downloads/climate_action_through_conservation.

Thorne, James H., Patrick R. Huber, Evan H. Girvetz, Jim Quinn, and Michael C. McCoy. 2009. "Integration of Regional Mitigation Assessment and Conservation Planning." *Ecology & Society* 14 (1): 1–27.

Tuppad, Pushpa, Kyle R. Douglas-Mankin, and Kent A. McVay. 2010. "Strategic Targeting of Cropland Management Using Watershed Modeling." *Agricultural Engineering International: CIGR Journal* 12 (3–4): 12–24.

U.S. Army Corps of Engineers. 2005. "Regulatory Guidance Letter." No. 05-09. http://www.usace.army.mil/Portals/2/docs/civilworks/RGLS/rgl05-09.pdf.

U.S. Army Corps of Engineers, Los Angeles District. 2012. "Regional General Permit Number 74 for Maintenance Activities within Special Area Management Plan Areas in Orange County, California." SPL-2010-01022-CJF. http://www.spl.usace.army.mil/Portals/17/docs/regulatory/RGP/RGP74.pdf.

U.S. Department of the Interior. 2003. "Guidance for the Establishment, Use, and Operation of Conservation Banks." https://www.fws.gov/endangered/esa-library/pdf/Conservation_Banking_Guidance.pdf.

U.S. Department of Transportation. 1995. "Memorandum of Understanding to Foster the Ecosystem Approach." https://www.fhwa.dot.gov/legsregs/directives/policy/memoofun.htm.

U.S. EPA. 1990. "Memorandum of Agreement between the Department of the Army and the U.S. Environmental Protection Agency: The Determination of Mitigation under the Clean Water Act Section 404(b)(1) Guidelines." https://www.epa.gov/cwa-404/memorandum-agreement.

———. 2007. "Water Quality Trading Toolkit for Permit Writers." https://www.epa.gov/sites/production/files/2016-04/documents/wqtradingtoolkit_fundamentals.pdf.

———. 2008. "Managing Wet Weather with Green Infrastructure." EPA-833-F-08-007. https://www.epa.gov/sites/production/files/2015-10/documents/gi_munichandbook_funding.pdf.

———. 2014. "Components of Credit Calculation." Technical Memorandum. https://www.epa.gov/sites/production/files/2015-07/documents/creditcalculationtm_final_5_14_14.pdf.

U.S. Fish and Wildlife Service. 2012. "Utah Prairie Dog (Cynomys Parvidens) Revised Recovery Plan." Denver, Colorado. https://www.fws.gov/mountain-prairie/species/mammals/utprairiedog/2012MarchRevisedRecoveryPlan_Final.pdf.

———. 2014. "Greater Sage-Grouse Range-Wide Mitigation Framework."

———. 2016. "Midwest Wind Energy Multi-Species Habitat Conservation Plan, Draft." http://midwestwindenergyhcpeis.org/documents/mww_hcp.pdf.

Van Pelt, William E., Sean Kyle, Jim Pitman, David Klute, Grant Beauprez, Doug Schoeling, Allan Janus, and Jonathan B. Haufler. 2013. "The Lesser Prairie-Chicken Range-Wide Conservation Plan." Cheyenne, Wyoming: Western Association of Fish and Wildlife Agencies. http://www.wafwa.org/Documents%20and%20Settings/37/Site%20Documents/Initiatives/Lesser%20Prairie%20Chicken/2013LPCRWPfinalfor4drule12092013.pdf.

Van Pelt, William E., Sean Kyle, Jim Pitman, Deb VonDeBur, and Michael Houts. 2015. *The 2014 Lesser Prairie-Chicken Range-Wide Conservation Plan Annual Progress Report*. Boise, Idaho: Western Association of Fish and Wildlife Agencies. http://www.wafwa.org/Documents%20and%20Settings/37/Site%20Documents/Initiatives/Lesser%20Prairie%20Chicken/LPC%20Annual%20final%20report%20033312015_FINAL%202.pdf.

Van Wye, Brian. 2012. "Making Stormwater Retrofits Pay." *Water Environment & Technology Magazine* 24: 64–67.

Vanderbilt, Forrest, Steven Martin, and David Olson. 2015. "The Mitigation Rule Retrospective: A Review of the 2008 Regulations Governing Compensatory Mitigation for Losses of Aquatic Resources." 2015-NaN-3. Institute for Water Resources. http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/2015-R-03.pdf.

"Virginia Aquatic Resources Trust Fund Program Instrument." n.d. http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/virginia/explore/the-virginia-aquatic-resources-trust-fund-home.xml.

Western Riverside County Regional Conservation Authority. 2003. "Multiple Species Habitat Conservation Plan." http://wrc-rca.org/Permit_Docs/mshcp_vol1.html.

Wilkinson, Jessica B., James M. McElfish Jr, Rebecca Kihslinger, Robert Bendick, and Bruce A. McKenney. 2009. "The Next Generation of Mitigation: Linking Current and Future Mitigation Programs with State Wildlife Action Plans and Other State and Regional Plans." Environmental Law Institute and The Nature Conservancy.

Wisconsin Department of Natural Resources. 2014. "Wisconsin Wetland Conservation Trust Instrument." http://dnr.wi.gov/topic/Wetlands/documents/mitigation/WWCTFinalSignedInstrument.pdf.

———. 2015. "Wisconsin Wetland Conservation Trust Annual Report for Fiscal Year 2015." Waukesha, Wisconsin. http://dnr.wi.gov/topic/Wetlands/documents/mitigation/WWCTAnnualReport.pdf.

Wolfe, David W., K. Brian Hays, Shannon L. Farrell, and Susan Baggett. 2012. "Regional Credit Market for Species Conservation: Developing the Fort Hood Recovery Credit System." *Wildlife Society Bulletin* 36 (3): 423–431.

Woodward, Richard T., and Ronald A. Kaiser. 2002. "Market Structures for US Water Quality Trading." *Review of Agricultural Economics* 24 (2): 366–383.

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