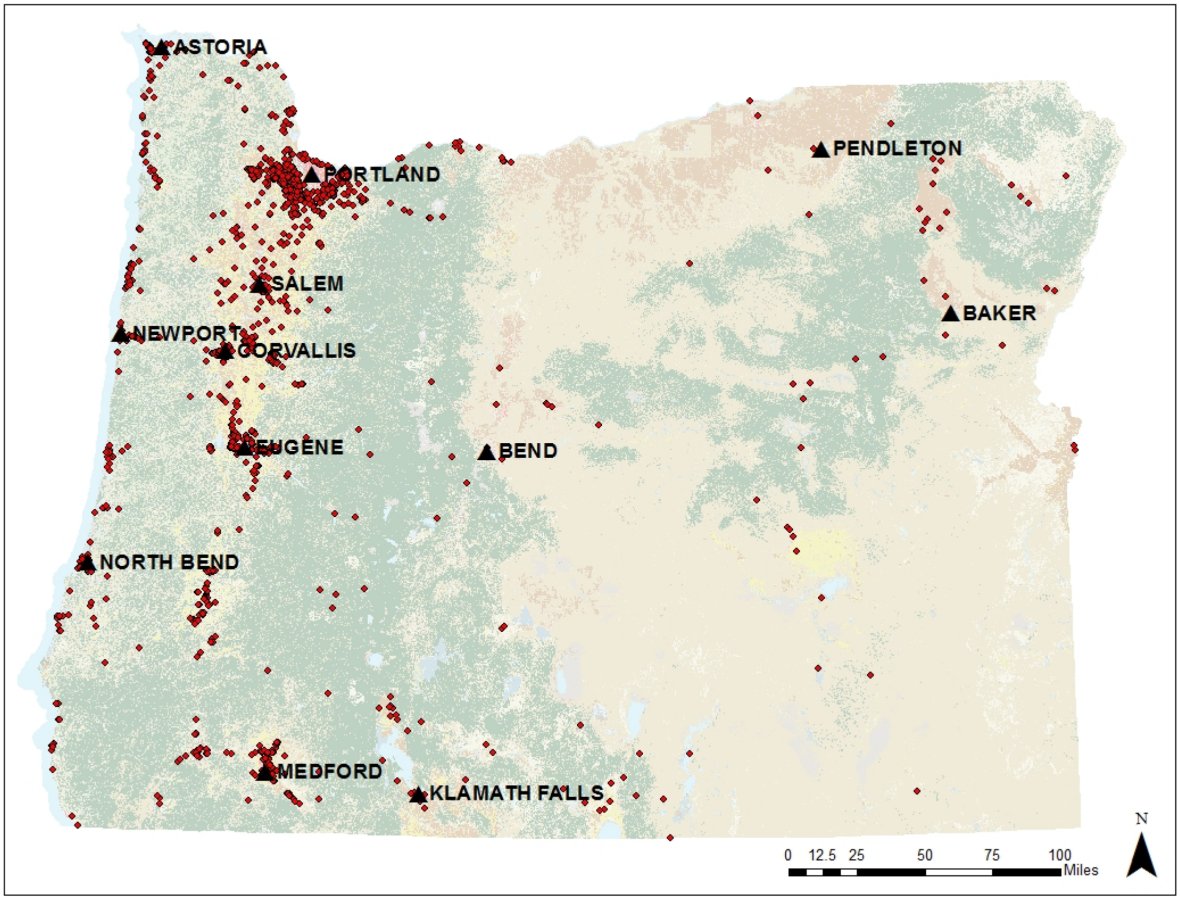
Oregon Compensatory Wetland Mitigation: Spatial and Temporal Patterns 2000-2016



Source: Author, data from Oregon Department of State Land (DSL) 2017, base map from 2011 Oregon NLCD Land Cover

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ABSTRACT

Development projects that have permanent wetland impact in Oregon require compensatory mitigation. This is often achieved through the creation, restoration, enhancement, perseveration, or use of other methods that offset the loss of wetlands caused by development. Historically, wetland mitigation has been measured on an acre-for-acre basis under a national policy of no-net loss of wetland acres. However, recent research has shown that the "acre-for-acre" policy is insufficiently maintaining the ecosystem services of permanently impacted wetlands.[1]

In 2008, the U.S. Army Corps of Engineers (ACOE) and U.S. Environmental Protection Agency (EPA) issued a new federal mitigation rule. The purpose of the rule was to increase the effectiveness of compensatory mitigation. Specifically, the rule called for setting mitigation decisions in the watershed context, where wetland functionality is quantified and maintained.[2]

In an effort to bring its compensatory mitigation program more in line with the federal rule, in 2015 the Oregon Department of State Lands (DSL) established the Oregon Aquatic Resource Mitigation Program (ARMP). The intent of the ARMP is to transition the state's compensatory mitigation program from an acres-based approach to a function-based accounting focus. As part of this process, DSL desired analyses of (1) historic wetland compensation actions in the state and (2) the degree to which current database systems are suited for evaluating the performance of Oregon's compensatory wetland mitigation regulations.

Few studies have examined the aggregate impact of individual wetland mitigation projects.[3] Further, no identified study has investigated how permanent wetland impacts and compensatory wetland mitigation actions in Oregon have varied spatially and temporally. This project provides a reproducible methodology for (1) analyzing the clustering of wetland loss and mitigation within regulatory watersheds; (2) analyzing the relationship of wetland mitigation and the type of wetland impacted, and (3) analyzing the relationship of wetland mitigation locations and ARMP defined priority conservation lands. These measurements can

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[1] Eliot, W. (1985). Implementing Mitigation Policies in San Francisco Bay: A Critique. Oakland, CA: California State Coastal Conservancy;

Race, M.S. (1985). Critique of Present Wetlands Mitigation Policies in the United States Based on an Analysis of Past Restoration Projects in San Francisco Bay. Environmental Management 9(1): 71-82;

Erwin, Kevin L. (1990). Wetland Evaluation for Restoration and Creation. In "Wetland Creation and Restoration: The Status of the Science," edited by J. A. Kusler and M. E. Kentula. Washington, DC: Island Press.;

Race, M.S. and M. Fonseca. (1996). Fixing Compensatory Mitigation: What will it take? Ecological Applications, 6 (1): 94-101.

[2] Compensating for Wetland Losses Under the Clean Water Act. (2001). National Research Council. Washington, DC: The National Academies Press. doi: 10.17226/10134;

Compensatory Mitigation for Losses of Aquatic Resources - Final Rule. (2008). Federal Register Vol. 73, No. 70.

[3] BenDor, T., Brozović, N., & Pallathucheril, V. G. (2007). Assessing the socioeconomic impacts of wetland mitigation in the Chicago region. Journal of the American Planning Association, 73(3), 263-282. DOI: 10.1080/01944360708977977

be used as part of the ARMP program evaluation to track changes in Oregon compensatory wetland mitigation over time.

This project analyzed 1,281 individual permitted development projects with permanent wetland impacts from 2000-2016. Of these individual development projects, 1,160 had associated wetland mitigation actions. Some developments utilized multiple compensation methods, and the final dataset analyzed contained 1,535 compensatory wetland mitigation transactions. Analysis was conducted at both the project permanent wetland impact level, and at the compensatory wetland transaction level.

This analysis shows that the average acreage of permanent wetland impacts has remained stable over the study period. That is, there has not been a shift in the amount of wetland permanently impacted by individual projects. The number of projects and total annual acreage has significant variation during the study period, but there is not a clear trend in the number of project or annual acreage of permanently impacted wetland.

Permanent wetland impacts show significant clustering in the Willamette Basin with just over 50% of permanent wetland impact acreage from 2000-2016 occurring in these three sub-basins. The historic wetland mitigation sites and wetland mitigation bank sites show some existing alignment with the Oregon Wetlands of Conservation Concern. There were nine mitigation banks and 71 mitigation actions taken within Wetland of Conservation Concern from 2000-2016. Overall, from 2000-2016 there has been a substantial shift in mitigation from permittee responsible mitigation to off-site mitigation with the use of mitigation banks.

INTRODUCTION

Wetlands are areas where water covers the soil, or is present either at or near the surface of the soil all year or for varying periods of time during the year.[4] Prior to the 1970s, significant draining and filling of wetlands occurred with the support of federal policies that sought to promote agricultural, commercial, residential development, and mosquito control.[5] Nationally, and here in Oregon, wetland area in the 1990s was found to have been decreased to 50% of historic levels.[6]

While wetlands were once considered to be sources of disease and impediments to development, they are now understood to be complex components of watershed ecosystems. Wetland ecosystem services can provide a number benefits to humans including improved water quality, natural flood control, diminished drought affects, groundwater and aquifer recharge, and stabilized shorelines. The historic wetland losses, and recognition of the ecosystem services provided by wetlands, have led to the development of significant federal and state wetland regulations over the past 50 years.

Federal and state regulations require that developments take steps to avoid and minimize impacts to wetlands. For the remaining unavoidable impacts, compensation is required via the creation, restoration, enhancement, perseveration, or us of other ways of offsetting the wetland impacts. Federal wetland regulations, based on Section 404 of the 1972 Clean Water Act (CWA), are enforced by the U.S. Army Corps of Engineers (ACOE) and U.S. Environmental Protection Agency (EPA).[7] Oregon's wetland policy pre-dates the CWA. Since 1967, the Department of State Lands (DSL) has developed and enforced wetland regulations under the state's Removal-Fill Law.[8]

The goal of these policies has been to prevent the net-loss of wetland acres both nationally and at the state level. As a result of the "no-net loss" policy, both the permanent wetland impacts occurring from development, and compensation for these effects, have been quantified on an acre-for-acre basis. The national effort to offset wetland impacts has slowed the loss of, and possible even led to gains in, wetland acreage at the national scale.[9]

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[4] What are wetlands? (n.d.). Environmental Protection Agency (EPA). https://www.epa.gov/wetlands/what-wetland

[5] Natural Resource Council, (2001). Compensating for Wetland Losses Under the Clean Water Act. Washington, DC: The National Academies Press. doi: 10.17226/10134.

[6] Dahl, T.E. (1990). Wetland Losses in the Unites States 1780's to 1980's. U.S. Department of the Interior, Fish and Wildlife Service. Washington, D.C;

Lev. E., (2009). Oregon's Greatest Wetlands. The Wetlands Conservancy. http://oregonexplorer.info/content/oregons-greatest-wetlands

[7] Natural Resource Council, (2001).

[8] Oregon Wetland Monitoring & Assessment Strategy. (2012). Oregon Department of State Lands. https://www.oregon.gov/dsl/WETLAND/docs/oregon_monitoring_assessment_strategy.pdf

[9] Wetlands. (n.d.). USDA Natural Resources Conservation Service http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/water/wetlands/

However, the ecosystem services provided by wetlands are not well accounted for, or maintained, under this acreage based compensatory wetland mitigation program. A 2001 comprehensive evaluation of wetland mitigation conducted by National Research Council (NRC) concluded that "the goal of no-net loss of wetlands is not being met for wetland functions."[10]

To address these concerns, the NRC report recommended that compensatory wetland mitigation decisions be made using a "watershed approach," as opposed to the current acreage based policy. In 2008, the ACOE and EPA issued a new federal mitigation rule to increase the effectiveness of compensatory mitigation that called for setting mitigation decisions in the watershed context.[11] While this provided direction for states to move, it did not provide guidance on how a watershed approach should be implemented.

Oregon's wetland mitigation policy increasingly seeks to require functional replacement of wetlands. Although the exact regulatory requirements vary geographically and have changed over time, in general the Department of State lands requires "in kind" replacement. In the regulatory framework, this means that the impacted wetland and compensatory wetland mitigation action must match wetland Cowardin system and class and hydrogeomorphic (HGM) class and sub-class.[12]

To align Oregon's Removal-Fill regulations with the 2008 federal rule, the Oregon Aquatic Resource Mitigation Program (ARMP) has been working since 2015 to transition the compensatory mitigation program from an acres-based accounting focus to one that better supports more function-based mitigation in a watershed context for impacted resources. This effort is ongoing and there is a clear need to better understand the effects of historic wetland impacts and compensation in Oregon such that the emerging program can be compared against the effects of the historic compensatory wetland mitigation policy.

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[10] Natural Resource Council, (2001).

[11] *Id;*,

Compensatory…, (2008).

[12] A Guide to the Removal-Fill Permit Process. (2016). Department of State Lands (DSL)

BACKGROUND

The need for government regulations to protect wetlands in the United States reached a tipping point in the 1980's when a congressional report found that wetland area in the contiguous United States had decreased to approximately 53% of what they had been in the 1780s.[13] Mirroring the national trend, Oregon has lost over half of the wetlands present when the first settlers arrived in the 1800s.[14] Prior to the 1970s, significant draining and filling of wetlands occurred with support of federal policies that sought to promote agricultural, commercial, residential development, and mosquito control through the conversion of wetlands.[15]

Wetlands are now widely recognized as complex components of watershed ecosystems that can provide a number benefits including improved water quality, natural flood control, diminished drought affects, groundwater and aquifer recharge, and stabilized shorelines.[16] Wetlands further support a large biodiversity of plants and animals including rare and endangered species, migratory birds, and the young of commercially valuable fishes and wetlands beauty and diversity contributes recreation values.[17]

While state and federal policy regulating wetlands are complex and involve numerous agencies, the following is a concise history of relevant policies and decisions that have led to the creation of the Oregon Aquatic Resource Mitigation Program (ARMP) in 2015. This research projects serves to support the continued development of the ARMP.

- In 1967, Oregon passed the Removal-Fill Law (ORS 196.795-990) to protect public navigation, fishery and recreational uses of "waters of the state," which include wetlands, while implementation and development of regulations was left to the Department of State Lands (DSL).[18]
- In 1972, the federal government's role in protecting wetlands began with the passage of the Clean Water Act (CWA) (Wetlands Programs …, 1996). Section 404 of the CWA established a program to regulate the discharge of dredged or fill material into waters of the United States, including wetlands, that is implemented by the Army Corp of Engineers (ACOE).[19]
- In 1987, Oregon enacted the Wetland Mitigation Bank Act that established the regulatory framework from mitigation bank operations.[20]

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[13] Dahl, T.E. (1990).

[14] Lev. E., (2009).

[15] Natural Resource Council, (2001).

[16] *Id.*

[17] *Id.*

[18] Oregon Wetland Monitoring & Assessment Strategy. (2012).

[19] 404 Regulatory Authority Fact Sheet. (2015). Environmental Protection Agency. https://www.epa.gov/sites/production/files/2015-03/documents/404_reg_authority_fact_sheet.pdf

[20] O.R.S 196.600-196.665. (1987).

- In 1988, then presidential candidate George Bush endorsed the national goal of “no-net loss” of wetlands, and during his first year in office the Environmental Protection Agency (EPA) announced this goal as an administrative policy.[21]
- In 1989, Oregon passed the Wetlands Conservation Act which promotes the protection, conservation and best use of wetland resources, their functions and values through the integration and close coordination of statewide planning goals, local comprehensive plans and state and federal regulatory programs.[22]
- In 1998, the goal of establishing wetlands beyond “no-net loss” was expanded on by President Bill Clinton through the Clean Water Act (CWA) Action Plan that clearly articulated his administration's goal of achieving a national net gain of 100,000 acres per year by 2005.[23]
- In 2004, President George W. Bush announced that “no-net loss” had been accomplished nationally, and that more wetlands had been restored or created than were being destroyed in the U.S. He further announced new policy beyond “no-net loss” to establish 3-million more acres of wetlands beyond those being lost.[24]
- In 2008, the U.S. Army Corps of Engineers (ACOE) and U.S. Environmental Protection Agency (EPA) issued a new federal mitigation rule to increase the effectiveness of compensatory mitigation. Specifically, the rule called for setting mitigation decisions in the watershed context, where wetland functionality is quantified and maintained.[25]
- In 2015, Oregon established the Aquatic Resource Management Program (ARMP) to develop and implement a watershed-based approach to stream and wetland mitigation.

The following section introduces the details of the current compensatory wetland mitigation policy that has resulted from these state and federal actions.

Compensatory Wetland Mitigation Policy

Under the overarching goal of “no-net loss” and eventual net gain, the Oregon Wetlands and Waterways Removal-Fill law and the federal Clean Water Act (CWA) 404 law regulate development that includes filling and removing materials from wetlands and waterways. To simplify the permitting process, the federal Army Corp of Engineers CWA 404 permitting process and the Oregon DSL Wetlands and Waterways Removal-Fill permitting process have been combined in a single regulatory process overseen by the DSL. Under current regulations, a permit is required if an activity will involve filling or removing 50 cubic yards or more of material in a wetland or waterway. For activities in state-designated Essential

[21] Wetlands, (n.d.).

[22] Oregon Wetland …, (2012).

[23] Sibbing, Julie. Nowhere Near No-Net-Loss. (2004) National Wildlife Federation.

[24] Wetlands, (n.d.).

[25] Compensatory Mitigation for Losses of Aquatic Resources - Final Rule. (2008).

Salmonid Habitat, State Scenic Waterways, and existing compensatory mitigation sites, a permit is required for any amount of removal or fill.[26]

Current requirements state that applicants whose development proposal will impact state wetlands or waterways must first consider, in the following order:

1. Avoiding the impact altogether;
2. Minimizing the impact;
3. Rectifying the impact at project completion; and
4. Compensating for the unavoidable losses. [27]

Commonly referred to as compensatory mitigation, requirement 4 involves creating, restoring, enhancing, preserving, or in other ways offsetting the lost wetland functions caused by a development. Temporary wetland impacts that occur during the development process, but that do not persist after development is complete, also require mitigation during the duration of the impact. However, these impacts are not addressed in this project as the effects are not permanent. Unavoidable losses, or permanent wetland impacts, are the focus of this project.

There are two large categories of compensatory wetland mitigation for permanent wetland impacts. The first is permittee responsible mitigation in which the permittee is responsible for the on-the-ground wetland mitigation. The second is non-permittee responsible wetland mitigation in which the permittee pays a fee to an outside group that is then responsible for the on-the-ground wetland mitigation.

The seven sub-categories of permittee responsible and non-permittee responsible compensatory wetland mitigation actions are summarized in the following table. The following subsections describe these allowed wetland mitigation actions.

Table 1: Types of Compensatory Wetland Actions

Action	Minimum Mitigation Acreage Ratio (mitigation:impact)	On or Off-Site*
Permittee Responsible Wetland Mitigation		
Wetland Creation	1.5:1	On or Off site
Wetland Restoration	1:1	On or Off site
Wetland Enhancement	3:1	On or Off site
Wetland Conservation	10:1**	On or Off site
Non-Permittee Responsible Wetland Mitigation		
Wetland Bank Credit Mitigation	na	Off-site
Fee-in-lieu (FIL) Mitigation	na	Off-site
Payment-in-lieu (PIL) Mitigation	na	Off-site

Source: Author
***on-site when compensation is within the tax lot(s) of the permanent wetland impact or within tax lots adjacent to permanent wetland impact tax lot(s), otherwise considered to be off-site mitigation**
****typical ratio, no minimum ratio has been designated**

[26] A Guide to the Removal-Fill Permit Process. (2016). Department of State Lands (DSL). www.oregon.gov/DSL/WW/Documents/Removal_Fill_Guide.pdf

[27] Wetland and Tidal Waters Mitigation Planning. (n.d.) Oregon Department of State Lands. https://www.oregon.gov/dsl/PERMITS/Pages/wetland_mitigation.aspx

Permittee Responsible Wetland Mitigation

Permittee responsible mitigation involves the creation, restoration, enhancement, or conservation of wetlands. The allowed methods of permitted responsible mitigation are described in the following table.

Table 2: Permittee Responsible Wetland Mitigation Types

Action	Description
Wetland Creation	The development of a wetland or other aquatic resource where a wetland did not previously exist through manipulation of the physical, chemical, and/or biological characteristics of the site.
Wetland Restoration	The reestablishment or rehabilitation of a wetland or other aquatic resource with the goal of returning natural or historic functions and characteristics to a former or degraded wetland.
Wetland Enhancement	Activities conducted within existing wetlands that heighten, intensify, or improve one or more wetland functions. Enhancement is often undertaken for a specific purpose such as to improve water quality, flood water retention or wildlife habitat. Enhancement results in a gain in wetland function, but does not result in a net gain in wetland acres.
Wetland Conservation	The permanent protection of ecologically important wetlands or other aquatic resources through the implementation of appropriate legal and physical mechanisms (i.e. conservation easements, title transfers). Preservation may include protection of upland areas adjacent to wetlands as necessary to ensure protection or enhancement of the aquatic ecosystem. Preservation does not result in a net gain of wetland acres and may only be used in certain circumstances, including when the resources to be preserved contribute significantly to the ecological sustainability of the watershed.

Source: Wetland Compensatory Mitigation. (n.d.). Environmental Protection Agency (EPA). https://www.epa.gov/sites/production/files/2015-08/documents/compensatory_mitigation_factsheet.pdf

Under special circumstances, a developer may be allowed to use "advanced mitigation." This approach involves the use of excess credits from a previously developed, permittee-responsible compensatory wetland mitigation site. Notably, this is not a common or widespread practice. While wetland creation, restoration, enhancement, or conservation are allowed mitigation actions, the ratio of mitigation acres to permanent wetland impact acres varies depending on the type of mitigation.

Minimum Compensation Ratios

In an ongoing effort to maintain wetland functionality, DSL has established minimum compensation acreage ratios based on the type of wetland mitigation (creation, restoration, enhancement, or preservation) undertaken. Under Oregon Administrative Rules, minimum ratios of wetland mitigation acreage versus permanently impacted wetland acres as 1.5:1 for created wetland, 1:1 for wetland restoration, 3:1 for wetland enhancement (2:1 for enhanced cropped wetlands)[28].[29]

This approach recognizes that replacing wetland function using restoration, enhancement or conservation techniques may require greater than a simple one-to-one compensation ratio. Notably, wetland preservation is allowed only on a case

[28] Cropped wetland is converted wetland that is regularly plowed, seeded and harvested in order to produce a crop for market.

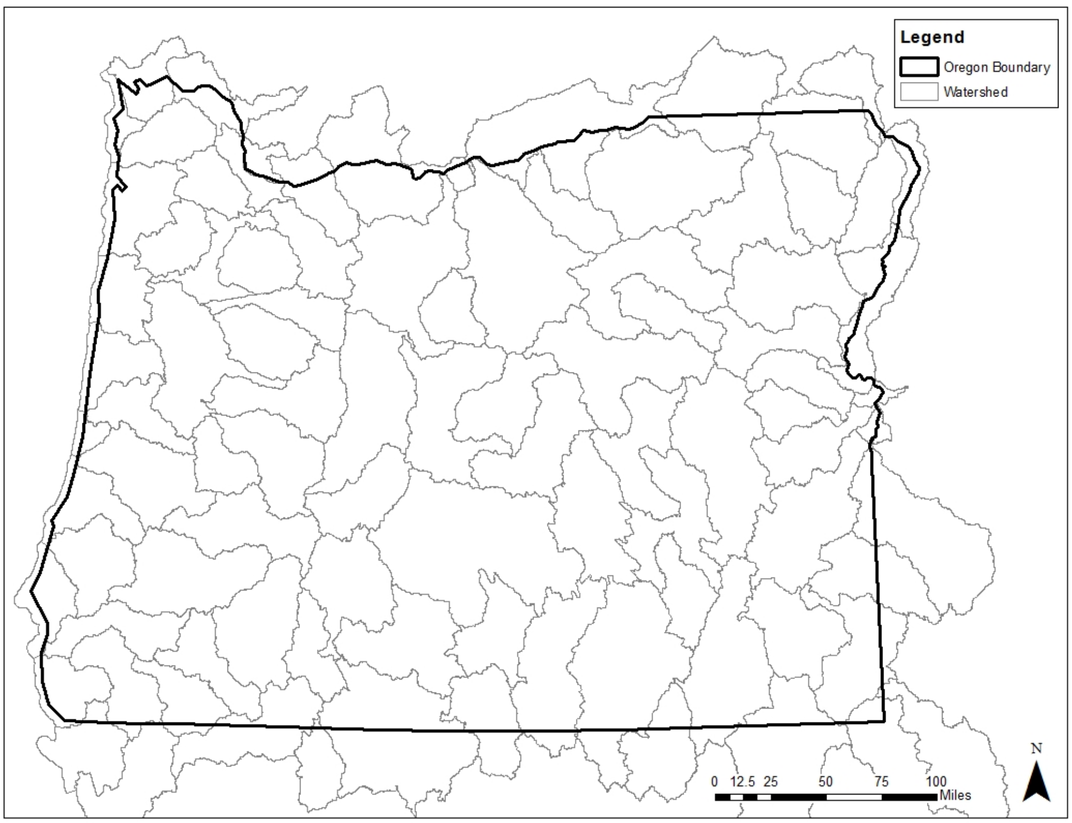
[29] Oregon Administrative Rule (OAR) 141-085-0690

by case basis. It does not have established minimum ratio, but it is typically enforced at a 10:1 or higher ratio. These mitigation action types may occur either on the site of the permanent wetland impact or off-site at a suitable location.

Permittee Responsible On-Site vs. Off-Site Mitigation

Mitigation is considered to have occurred on site when it is within the tax lot(s) of the permanent wetland impact, or within tax lots adjacent to permanent wetland impact tax lot(s).[30] When the mitigation action occurs outside of the tax lot(s) of the impact of adjacent tax lot(s), then the mitigation is classified as offsite. Offsite mitigation must occur within the 8th field sub-basins, commonly referred to as hydrologic unit code eight (HUC8), of the project's permanent wetland impact to prevent the dislocation of the wetland services.[31]

Figure 1: Oregon HUC8 Sub-Basins



Source: Author, boundaries from Oregon Watershed Boundary Dataset

Wetland Bank Credit Mitigation

Mitigation banks became an allowed tool for off-site wetland mitigation when policies established their use in the early 1990s, but their use in Oregon was not widespread until the past decade.[32] A wetland mitigation bank is a relatively large

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[30] A Guide to the Removal-Fill Permit Process. (2016). DSL

[31] Personal communications with Dana Hicks. (2017). DSL

[32] Mitigation Banking Factsheet. (1995). Federal Register Volume 60, Number 228 Page 58605-58614

contiguous tract of wetlands that have been restored by a third-party. The bank developer permanently manages and protects these wetlands and their natural resource values. The bank's wetland restoration is translated into quantifiable "wetland credits." These credits can be sold on the open-market as an off-site means of satisfying permanent wetland impact mitigation requirements. The credit price includes funding for the long-term natural resource management and protection of those values and the price of credits is market based and varies from mitigation bank to mitigation bank.

Like permittee responsible off-site mitigation, projects are only eligible to use mitigation banks that occur within a constrained geography.[33] When a mitigation bank is created, a service area in which credits may be bought and sold is designated. This can be, but is not always, similar to the 8th field HUC (hydrologic unit code) sub-basins used for permittee responsible off-site mitigation.[34]

Mitigation banking has environmental, administrative, and permittee benefits when compared with permittee responsible on or off-site mitigation. From the environmental perspective, conservation banking reduces the piecemeal approach to conservation efforts that can result from individual projects by establishing larger reserves and enhancing habitat connectivity. From the administrative perspective, mitigation banking simplifies the review of permittee mitigation and reduces the number of mitigation sites whose performance needs to be monitored and checked over time. From a project applicant's perspective, mitigation banking saves time and money by identifying pre-approved conservation areas, identifying "willing sellers," increasing flexibility in meeting their conservation needs, and simplifying the regulatory compliance process and associated paperwork. Further, mitigation banking provides land owners of potential bank sites an opportunity to generate income from a landscape feature that may have previously been considered a liability.[35]

Wetland mitigation banking is part of a larger movement of ecosystem banking that develops transferable credits for diverse ecosystem services such as water temperature, carbons sequestration, and wetland functions. Although ecosystem banking in Oregon is relatively new with the clear majority of conservation banks offering only wetland credits, the legal framework and support for conservation banking is growing. The Oregon Conservation Strategy calls to:

> Expand conservation banking to a statewide approach. Conservation banking has been developed to provide options for regulatory compliance and can be a more simple and economical option for meaningful mitigation for unavoidable impacts, resulting in a win-win outcome if designed well. Today, the concept of conservation banking is expanding, presenting new options.[36]

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[33] A Guide to the Removal-Fill Permit Process. (2016). DSL

[34] Personal communications with Dana Hicks. (2017). DSL

[35] Wetland Mitigation Banking Guidebook for Oregon. (2000).

[36] Oregon Conservation Strategy. (2016). Chapter 2, pg 81. Oregon Department of Fish and Wildlife.

While the use and establishment of mitigation banking is expanding, Oregon also operates a state program similar in function to mitigation banking call the Fee-in-Lieu program that seeks to provide many of the same wetland mitigation benefits as seen in the private mitigation banking system.

Fee-in-Lieu (FIL) Wetland Mitigation

In Oregon, Fee-in-lieu (FIL) mitigation provides another alternative to permittee responsible mitigation. Under the FIL program, the state undertakes wetland mitigation in the sub-basins where conditions exist that prevent the operation of a wetland mitigation bank.[37] The state performs mitigation of enough wetland acres in these prioritized service areas to meet current and expected demand for wetland credits from development project[38] These FIL credits can then be purchased to satisfy compensatory wetland mitigation for permanent wetland impacts.

According to the Departments of State Lands, the FIL mitigation program provides three primary benefits:

1. It minimizes the temporal loss of wetlands by developing mitigation projects in advance of mitigation needs;
2. It maintains a level of accountability commensurate with mitigation banks, such that mitigation obligations assumed by DSL are met in a timely and effective manner; and,
3. It achieves ecologically significant restoration projects that sustain aquatic resource functions and services consistent with a watershed approach.[39]

Oregon Department of State Lands (DSL) developed a four-prong test to identify and establish seven priority watersheds for FIL wetland mitigation. The state looked at (1) the past mitigation needs in the watershed based on historical permitted impacts; (2) the future need for mitigation in the watershed based on projected growth and development trends; (3) the lack of private mitigation banks to meet the demand for credits in the service area; and, (4) the availability of funds in the 3rd field sub-basins of the state.[40]

Payment-in-Lieu (PIL) Wetland Mitigation

When the permittee cannot identify on or off-site permittee responsible mitigation actions and there is neither a mitigation bank or FIL credits available, then the Department of State Lands payment-in-lieu (PIL) mitigation program may be used to fulfill required compensatory wetland mitigation.[41] Both the mitigation bank program and the FIL program sell credits for mitigation of wetland acres that has

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[37] 4th field sub-basins (HUC4) west of the Cascade Mountains and as 3rd field sub-basins (HUC3) east of the Cascades

[38] Oregon Department of State Lands Statewide Fee-in-Lieu Instruments. (2008). Oregon Department of State Lands (DSL).

[39] *Id.*

[40] *Id.*

[41] Purpose of Mitigation. (n.d.) Oregon Department of State Lands (DSL). http://www.oregon.gov/dsl/WW/Pages/Mitigation.aspx

already occurred. In contrast, the PIL program collects funds for mitigation that has yet to occur. Therefore, the PIL program can have a significant temporal dislocation of wetland mitigation as the impact and compensation may be separated by months or years.

The PIL program is not a recognized compensation method under Section 404 of the Clean Water Act as implemented by the Army Corp of Engineers. Therefore, the PIL program is only available for projects where the state requires compensation but the Corp does not.[42] After a permittee has purchased state PIL credits, the mitigation obligation is transferred to the Department of State Lands.

In-Kind Compensatory Wetland Replacement

While Oregon's compensatory wetland mitigation program has been historically based on the "no-net loss" doctrine as quantified by the total acreage of wetlands, this is not to say that there has not already been consideration for maintaining wetland functions. Oregon's wetland mitigation policy increasingly seeks to require functional replacement of wetlands. Although the exact regulatory requirements vary geographically and have changed over time, in general the Department of State lands requires "in-kind" replacement. In the regulatory framework, this means that the impacted wetland and compensatory wetland mitigation action must match wetland Cowardin system and class and hydrogeomorphic (HGM) class and sub-class.[43]

Wetland Cowardin Classification

The Cowardin wetland classifications schema was developed in 1979 as part of the National Wetland Inventory.[44] The Cowardin schema is relatively straightforward as it is based on vegetation structure and water regimes, that can be identified from aerial photography or be inferred from knowledge of local or regional conditions.[45]

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[42] *Id.*

[43] A Guide to the Removal-Fill Permit Process. (2016). DSL

[44] Cowardin, L.M., V. Carter, F.C. Golet & E.T. LaRoe. (1979). Classification of wetlands and deepwater habitats of the United States. USDI Fish & Wildlife Service, Biological Services Program. FWS/OBS-79/31.

[45] Wetland Classification. (n.d.) Oregon Explorer: Natural Resources Digital Library. http://oregonexplorer.info/content/wetland-classifications

Table 3: Oregon Wetland Cowardin Classification

System	Sub-system
Estuarine	Subtidal
	Intertidal
Riverine	Tidal
	Lower Perennial
	Upper Perennial
	Intermittent
	Unknown Perennial
Lacustrine	Limnetic
	Littoral
Palustrine	n/a

Source: Guidebook for Hydrogeomorphic (HGM)–based Assessment of Oregon Wetland and Riparian Sites: Statewide Classification and Profiles. (2001). Oregon Department of State Lands (DSL).

Wetland Hydrogeomorphic Classification

The hydrogeomorphic (HMG) schema for classifying wetlands was first proposed in 1994 by Brinson and since been widely adopted by scientists and wetland managers.[46] Brinson's classification differs from the Cowardin classification in that it utilizes many factors external to a wetland and requires onsite inspection to determine classification. Site visits allow for the determination of the "landscape setting" or "landscape position" that affects a wetlands annual water amounts, preciosity, and chemistry. These water and water quality fluctuations are responsible for maintaining most wetland functions.[47]

An in-depth review of wetland science and classification schema lead Oregon to adopt 14 HGM subclasses of Brinson's national HGM classification as seen in the following table.

[46] Guidebook for Hydrogeomorphic (HGM)–based Assessment of Oregon Wetland and Riparian Sites: Statewide Classification and Profiles. (2001). Oregon Department of State Lands (DSL).

[47] *Id.*

Table 4: Oregon Wetland Hydrogeomorphic Classification

Classification	Sub-Classifications
Riverine	Flow-through
	Impounding
Depression	Closed Permanently
	Flooded Closed
	Non-permanently Flooded
	Outflow
	Alkaline
	Bog
Slope	Headwater
	Valley
Flats	na
Lacustrine Fringe	Headwater
	Valley
Estuarine Fringe	River-sourced
	Embayment

Source: Guidebook for Hydrogeomorphic (HGM)–based Assessment of Oregon Wetland and Riparian Sites: Statewide Classification and Profiles. (2001). Oregon Department of State Lands (DSL).

Effects of Historic Compensatory Wetland Mitigation

Despite efforts to use Cowardin and HGW wetland classification as proxy for wetland functionality, research suggests that wetland functionality is not being fully maintained under this current regulatory model. A crucial conclusion from the 2001 National Resource Council (NRC) Report is that "the goal of no net loss of wetlands is not being met for wetland functions by the mitigation program, despite progress in the last 20 years." This conclusion is supported by considerable literature that has shown that aquatic resource functions are not being maintained under this framework.[48]

The result of these studies has been a move towards compensatory mitigation that take progressive approaches that go beyond "no net loss," to achieve greater environmental benefit, and promote ecosystem sustainability.[49] The 2001 National Resource Council Report concludes that "a watershed approach would improve

48 Eliot, W. (1985). Implementing Mitigation Policies in San Francisco Bay: A Critique. Oakland, CA: California State Coastal Conservancy;

Race, M.S. (1985). Critique of Present Wetlands Mitigation Policies in the United States Based on an Analysis of Past Restoration Projects in San Francisco Bay. Environmental Management 9(1): 71-82;

Erwin, Kevin L. (1990). Wetland Evaluation for Restoration and Creation. In "Wetland Creation and Restoration: The Status of the Science," edited by J. A. Kusler and M. E. Kentula. Washington, DC: Island Press.;

Race, M.S. and M. Fonseca. (1996). Fixing Compensatory Mitigation: What will it take? Ecological Applications, 6 (1): 94-101.

49 Brown 2006; Wilkinson et al. 2009

permit decision making." In 2008, the ACOE and EPA issued a new federal mitigation rule to increase the effectiveness of compensatory mitigation and called for setting mitigation decisions in the watershed context.[50]

A Watershed Approach to Compensatory Mitigation

The 2008 Compensatory Mitigation for Losses of Aquatic Resources - Final Rule calls for "improv[ing] the planning, implementation and management of compensatory mitigation projects by emphasizing a watershed approach in selecting compensatory mitigation project locations, requiring measurable, enforceable ecological performance standards and regular monitoring for all types of compensation and specifying the components of a complete compensatory mitigation plan, including assurances of long-term protection of compensation sites, financial assurances, and identification of the parties responsible for specific project tasks."

The Federal Ruling promotes the use of environmental function and condition assessment to determine appropriate mitigation in contrast to the current acreage based approach.[51] This approach is supported by research that shows aquatic resource functions are better preserved through coordinated mitigation and restoration efforts that occur throughout a watershed, as opposed to the current site-by-site based approach that does not consider watershed effects.[52] The cumulative effects of multiple projects in the same reach of stream or watershed can be greater than the combined impact of the same projects in different watersheds, and the current approach to compensatory mitigation fails to account for the distribution of projects within and across watersheds.

Recognizing this, the federal ruling shifted the preference for on-site, in-kind mitigation to in-kind mitigation with a watershed approach.[53] However, while the federal ruling calls for the adoption of a watershed approach, it provides little direction on how this should be implemented. Since 2008, states have begun to implement a watershed approach through statewide approaches or in watershed specific pilot projects.[54]

Watershed Management in Oregon: Aquatic Resource Mitigation Program

The Aquatic Resource Mitigation Program (ARMP) is a "statewide program covering all aquatic resources that defines a watershed approach and uses function-based assessments to quantify compensatory mitigation requirements."[55] To better meet

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[50] Compensatory…, 2008

[51] ARMP Fact Sheet. (2016) Personal Communication with Dana Hicks, Department of State Lands (DSL) Mitigation Policy Specialist.

[52] Bedford. (1999).

[53] Cecilia S. (2014) Implementing a Watershed-Based Approach for Aquatic Resource Mitigation in Oregon. Oregon Department of State Lands.

[54] *Id.*

[55] Ryan, B. (2016). The Development of Oregon's Aquatic Resource Mitigation Framework.

Oregon Department of State Lands. http://www.aswm.org/state_meeting/2016/ryan_033016.pdf the goals of Oregon's Removal-Fill Law and the Clean Water Acts of replacing the functions of wetlands lost from unavoidable impacts, the Oregon compensatory mitigation program is transitioning from the current acres-based accounting focus to one that better supports more function-based mitigation for impacted resources. The ARMP aims to establish policies that promote a watershed approach to mitigation, replace acreage-based mitigation with a function-based accounting method, develop stream mitigation policies that parallel the wetland mitigation program, and coordinate permitting processes between state and federal regulatory programs.[56] As a step in this direction, the Oregon Rapid Wetland Assessment Protocol (ORWAP) for assessing wetland functions and values was first developed in 2009 and is currently in its 3rd version.[57] This tool has seen increasing use across the state for assessing wetland impacts and compensation.

ARMP Priority Conservation Lands

The ARMP has identified seven existing priority conservation land types and is interested in better aligning wetland compensation actions with these lands. Quantifying the historic alignment of wetland compensation locations with these areas will provide the ARMP with a baseline measurement that the future program can be compared against.

Table 5: ARMP Priority Conservation Lands

Data	Source
Critical Habitat for Aquatic Resource Dependent Species	U.S Fish and Wildlife
Oregon Watershed Restoration Inventory	Oregon Watershed Enhancement Board
Federal Restoration Activities	Bureau of Land Management, US Forest Service
Essential Salmonid Habitat	Department of State Lands
Important Bird Areas	Audubon Society
Conservation Opportunity Areas	Oregon Department of Fish and Wildlife
Wetlands of Conservation Concern	Institute for Natural Resources (Oregon State University), The Wetlands Conservancy

Source: Author, personal communication with Dana Hicks. (2017).

Research Questions

Compensatory wetland mitigation in Oregon is a highly complex regulatory process involving seven different allowed actions and two complex wetland classification schemas. This project seeks to provide spatial and temporal analysis of permanent wetland impacts and compensatory wetland mitigation actions to quantity and describe the results of Oregon's wetland regulation.

In specific, this project seeks to address the following questions:

[56] ARMP Fact Sheet. (2016).

[57] Adamus, P., Verble, K.,and Rudenko, M., (2016). Manual for the Oregon Rapid Wetland Assessment Protocol (ORWAP, revised) Version 3.1. Department of State Lands (DSL).

1. What are general temporal and geographic patterns and trends in Oregon's compensatory wetland mitigation program?

A historic statewide evaluation of Oregon's compensatory mitigation program records has not been conducted. The current database structure is designed for the tracking of individual projects and is not well suited to evaluating historic and geographic patterns of permanent wetland impacts and compensation. Transforming the historic records into summary tables will allow permanent wetland impact sizes, locations, and types of mitigation utilized to be analyzed temporally and geographically providing insight into the effects of wetland policy and regulation changes over the past 16 years.

2. What is the clustering of wetland loss and mitigation within regulatory watersheds?

The cumulative effects of multiple projects in the same reach of stream or watershed can be greater than the combined impact of the same projects in different watersheds.[58] Additionally, studies have shown that when mitigation sites are selected outside of the affected watershed that the compensation does not contributing to maintaining the overall health of the watershed being impacted, despite that fact that there has been no-net loss of wetland acres across the multiple watersheds.[59]

This provides rationale for analyzing both the location of projects with compensatory mitigation to assess if there is clustering of development projects within watersheds and for analyzing if compensation for projects is occurring within the affected watershed or outside of it. Watersheds with clustered permitted projects or watersheds that have exported wetland compensation may be targets for adopting a stronger watershed management approach.

3. What is the relationship between wetland mitigation actions and the type of wetland impacted?

An analysis of wetland mitigation sites in the Cuyahoga River Watershed of Ohio revealed that although there was a net gain of wetland resulting from 23 permitted projects, that there was an overall decrease in wetland diversity because wetlands that were being impacted were being replaced with more common open water wetlands.[60] Oregon's regulatory preference for "in-kind" wetland compensation helps to prevent the replacement of complex wetlands with simple ones, but it is currently unclear if the type of wetland impacts the type of mitigation chosen. The "in-kind" regulations allows for analyzing the choice of compensatory wetland mitigation utilized by wetland classification.

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[58] Bedford, B.L. (1999). Cumulative effects on wetland landscapes: Links to wetland restoration in the United States and Southern Canada. Wetlands 19(4):775–788.

[59] Kettlewell, C.I., Bouchard, V., Porej, D. et al. (2008).

[60] Kettlewell, C.I., Bouchard, V., Porej, D. et al. (2008). An assessment of wetland impacts and compensatory mitigation in the Cuyahoga River Watershed, Ohio, USA. Wetlands 28: 57. doi:10.1672/07-01.1

4. What is the relationship of wetland mitigation locations and ARMP defined priority conservation lands?

Having a compensatory mitigation site located in close proximity to conservation or protected lands can contribute to increasing a created, enhanced or restored wetland's success in compensating for losses by increasing its connectivity, size, and overall contributions to wetland functions in that watershed.[61] Furthermore, habitat loss and fragmentation are widely recognized as the greatest threats to biodiversity, and a recent reviews of scientific literature on this topic revealed that maintaining "connectivity sufficient to sustain natural patterns of wildlife movement and permit adaptation" is the top recommendation for counteracting these threats.[62]

This provides rationale for analyzing Oregon's compensatory mitigation in relation to existing conserved lands and identified conservation priority areas to assess if wetland compensation is, or could be, strengthening overall conservation efforts in Oregon.

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[61] National Cooperative Highway Research Program (NCHRP). (2010). "Task 1: Literature Review and Interviews." Project 25-25, Task 67. Optimizing Conservation and Improving Mitigation Cost/Benefit;

Kramer, Elizabeth A., & Carpenedo, Steven. (2009). A Statewide Approach for Identifying Potential Areas for Wetland Restoration and Mitigation Banking in Georgia: An Ecosystem Function Approach. http://www.gwri.gatech.edu/sites/default/files/files/docs/2009/2.6.1_Kramer.pdf

[62] Connectivity 101. (n.d.). LandScope America. Accessed March 15, 2016. http://www.landscope.org/explore/natural_geographies/wildlife_connections/connectivity _101/#Heller

METHODOLOGY

The Oregon Department of State Lands sought a reproducible project methodology that transforms the raw data exported from the Land Administration System (LAS) into the necessary tables for this project's analysis. To accomplish this, an annotated R Markdown script was written to output the tables used for analysis (Appendix B). The dataset provided by DSL and the methodology utilized to address each research question are described in the following sections.

Dataset

The data used for this project was provided by the Oregon Department of State Lands (DSL) as an ArcMap geodatabase and mxd file. Records from 2000-2016 from the LAS databases were provided by Dan Antonson, DSL GIS Specialist. The 2000-2016 time frame of analysis was selected by DSL as prior to 2000 location records for projects were recorded as "centroid of section" and are not appropriate for performing spatial analysis.

Source data was exported from the DSL Land Administration System (LAS) and the associated Removal Fill (RF) and Resource Gains and Losses (RGL) tables. These tables are stored in relational databases that are linked by a unique project id value.

This structure type is well suited to inputting and retrieving information on a single project's permanent wetland impact(s) and compensatory wetland mitigation action(s). However, the existing relational databases do not allow for the spatial and temporal queries needed to answer this project's research questions.

Two summary tables were required for this project's analysis. The first summary table has a single row for each individual project with its permanent wetland impact acreage, its location, the date of the wetland impact, and the types of mitigation actions taken to offset the impact. The second table has a single row for each mitigation action that was taken to offset permanent wetland impacts from 2000-2016 and the HGM and Cowardin classification associated with each of the mitigation actions.

Table 6: Summary of Data Sources

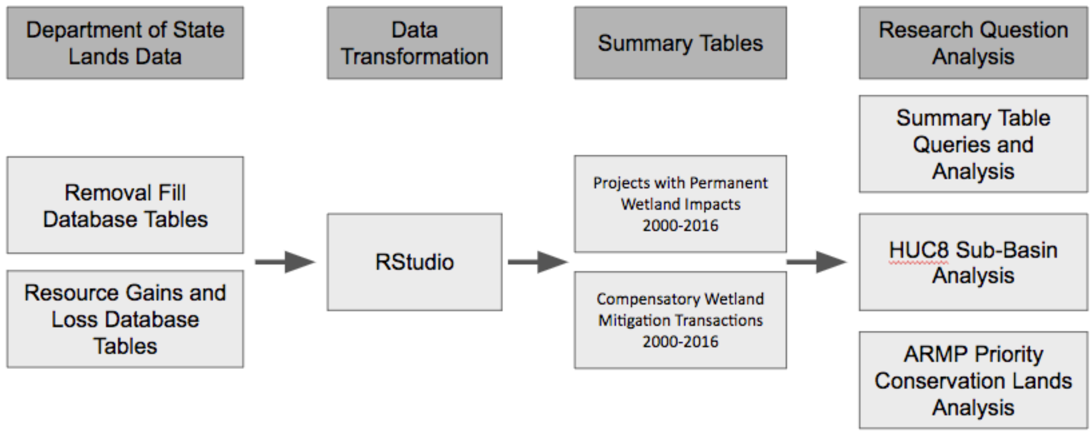
Feature Classes	Description
Department of State Land Database Outputs	
dbo_site_refs_pts	All locations from Land Adminsitration System (LAS) associated in some way with a DSL record of Regulatory or Proprietary (Land/Ownership Management) activities.
dbo_site_refs_app_pts	All records from dbo_site_refs_pts that are related to a DSL Application for Regulatory or Proprietary programs and occurred from 2000-2016.
dbo_site_refs_mit_pts	These are records from dbo_site_refs_pts that are related to an RGL record that are not part of a DSL Application.
MitigationBanks_pts	These points represent the location of Wetland Mitigation Banks. These are developed from a combination of Mitigation Bank records and the associated Site record in the LAS database.
RGL_Report_Sites_pts	These points represent all locations referenced by records in the RGL_GainsLoss_Report table. This table contains impact and mitigation notes within the Site_Name_1 field.
Analysis Summary Tables	
Projects with Permanent Wetland Impacts 2000-2016	Each row represents a single project with permanent wetland impacts summarized by total acres of wetland impacted and associated mitigation actions from 2000-2016.
Compensatory Wetland Mitigation Transactions 2000-2016	Each row represents a single compensatory wetland mitigation transaction and wetland GHGM and Cowarding classificationfrom 2000-2016.

Source: Author, Oregon Department of State Lands (2017).

Project Methodology Overview

To assess this project's research questions, it was first necessary to convert the Department of State Lands (DWL) relational data table structure to joined summary tables for analysis. This was accomplished in the data transformation step that used an RSMarkdown Script (see Appendix B) to convert the DSL tables into the two project summary tables. These two summary tables were then analyzed and compared against the HUC8 Sub-Basins and the ARMP Priority Conservation Lands. The specifics of the analysis methodology for each research question are provided in the following section.

Figure 2: Project Methodology Diagram



Source: Author

Research Question Methodology

1. What are general temporal and geographic patterns and trends in Oregon's compensatory wetland mitigation program?

The DSL removal fill and resource gains and loss database are a set of relational data tables linked by one or more common attribute fields. This data structure is efficient from a computer memory and data selection standpoint. However, it is not well suited to answering the following research questions that look at both the permanent wetland impact and the compensatory actions taken on a project by project basis or that look at all compensation by HGM or Cowardin classification. An annotated RMarkdown script (Appendix B) was written that converts the relation data tables into the two project summary tables for analysis.

The summary tables provide a data structure for tracking temporal and geographic changes in permanent wetland impacts and compensation. Annual summary statistics of permanent wetland impact and time series plots of mitigation types used will provide insight into how compensatory wetland mitigation has, or has not, changed over the past 16 years.

2. What is the clustering of wetland loss and mitigation within regulatory watersheds?

To analyze the clustering of permanent wetland impacts within regulatory watersheds the records from summary Table 1 - Projects with Permanent Wetland Impacts 2000-2016 were geolocated in ArcMap. Then the Hydrologic Unit Code 8th level sub-basin shapefiles from the Oregon Watershed Boundary Dataset were imported.[63] A spatial join was used to attach the associated sub-basin geography with each permanent wetland impact record. Summary statistics for the number of projects and total permanent wetland impact acreage in each sub-basin were then

[63] Oregon Watershed Boundary Dataset. (2014). Pacific Northwest Hydrography Framework. http://www.pnwhf.org/water-bound-dataset.aspx

calculated. Outputs from this analysis include the number of project and permanent wetland impact acreage by sub-basin in Oregon.

3. What is the relationship between wetland mitigation actions and the type of wetland impacted?

Summary Table 2 - Compensatory Wetland Mitigation Transactions 2000-2016 contains both the type of wetland mitigation and the HGM and/or Cowardin classification of the wetland. A query was used to count the number of mitigation transaction for each HGM class and type of wetland compensation utilized. Outputs from this analysis include tables of the HGM or Cowardin classification of the permanently impacted wetland and the type of compensation used to mitigate these impacts.

4. What is the relationship of wetland mitigation locations and ARMP defined priority conservation lands?

Wetland compensation sites and mitigation banks were selected and geocoded in ArcMap. The ARMP priority conservation datasets were downloaded as point, line, and polygon features. A quarter mile and half mile buffer around the point, line, and polygon features for each dataset were created. The resulting buffer polygons were then dissolved. The number of mitigation sites and mitigation banks within the unbuffered and buffered polygon were the counted using a spatial selection. Outputs include a table with the count of compensation actions and wetland mitigation banks both fully within and within a quarter mile buffer of ARMP priority conservation lands.

Data Limitations

Several data limitations were identified during the study. First, the DSL database likely contain human data entry errors. To the extent possible these were identified and their records excluded. However, the size of the data sets analyzed prevented a complete manual check of each record. Next, the analysis assumed that all compensation was fully successful. That is, this analysis did not look at records of how the mitigation site is performing or if the mitigation was fully completed. This matters as research has shown that compensatory wetland performance can often be less than that of the permanently impacted wetlands. Finally, the analysis of wetland mitigation bank transactions used the HUC8 sub-basin geographies as their service areas. While this a generally valid approximation of the mitigation bank service area, some banks do have approved service areas that differ from these sub-basins. This issue remains unresolved in this work.

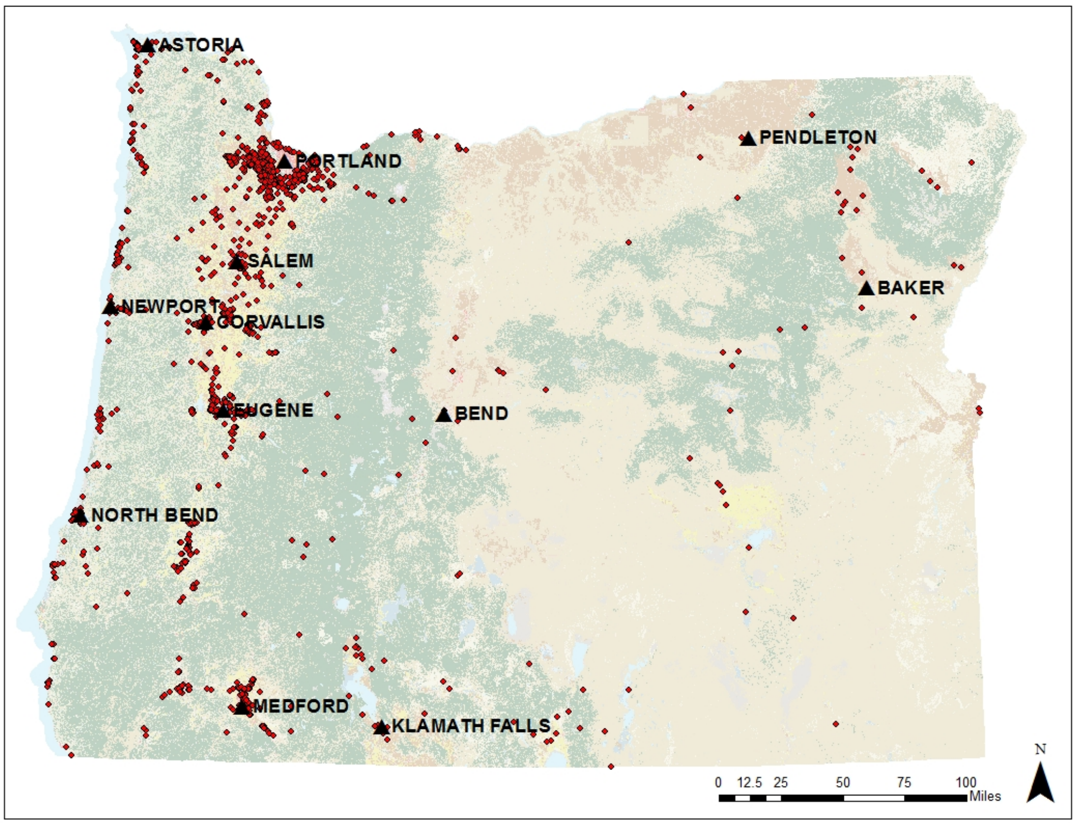
RESULTS

The following subsections provide the results of this project's data analysis. Implications of these results as they relate to the goals of the Oregon ARMP and this project's guiding questions are considered in the following discussion section of this report.

Permanent Wetland Impacts 2000-2016

From 2000-2016, there were 1,281 unique projects in Oregon that had permanent wetland impacts and compensatory wetland mitigation records in the DSL database.[64] The following map shows the locations of these projects. Projects are indicated with dots that do not reflect the acreage of wetlands permanently impacted, only the location of the impact. There is a clear concentration of projects at urban centers and cities along the coastline and I-5 corridor with more disperse impacts in the Eastern two-thirds of the state.

Figure 3: Permanent Wetland Impact Sites 2000-2016



Source: Author, data from Oregon Department of State Land (DSL) 2017, base map from 2011 Oregon NLCD Land Cover

[64] Differentiated by having a unique parent_id value, a single parent_id project may affect multiple wetland sites within its project boundaries.

Permanent Wetland Impact by HUC8 Geography

Under the current regulations, the 8th unit HUC (hydrologic unit code) geography is the regulatory unit in which the permanent wetland impact and compensation actions must, generally, occur within. Table 7 contains the number of projects with permanent wetland impacts and the total acreage for all affected HUC geographies that are inside, or partially within, Oregon.

The Upper Willamette HUC8 geography had the largest permanent wetland impact during the study period with over 360 acres permanently impacted. This is double the total impact of the second highest HUC8 geography, the Middle Willamette. This area saw 180 acres of permanent wetland impact. The Upper, Middle, and Lower Willamette HUC8 geographies account for 51% of the total permanent wetland impact acreage in Oregon from 2000-2016.

Table 7: Permanently Impacted Acres by HUC8 Geography

HUC8 Name*	Permanent Wetland Impact Projects	Total Impacted Wetland Acres	HUC8 Name* (continued)	Permanent Wetland Impact Projects	Total Impacted Wetland Acres
Upper Willamette	184	368.39	Sixes	12	4.40
Middle Willamette	85	180.47	Necanicum	15	4.01
Lower Willamette	97	109.82	Upper Grande Ronde	10	2.22
Tualatin	247	73.43	Silvies	6	1.89
South Umpqua	39	67.06	Warner Lakes	5	1.76
Middle Rogue	90	66.55	Powder	3	1.70
Coast Fork Willamette	14	40.18	Brownlee Reservoir	2	1.69
Lost	6	38.65	Wallowa	3	1.67
Coos	24	35.52	Alsea	6	1.56
Yamhill	15	32.13	North Santiam	6	1.45
Sprague	4	22.54	Goose Lake	6	1.28
Wilson-Trusk-Nestuccu	23	21.76	Chetco	6	1.21
Middle Fork Willamette	12	19.45	Middle Snake-Payette	2	1.15
Lower Columbia	31	18.21	Donner und Blitzen	3	1.13
Clackamas	50	17.41	Middle Fork John Day	2	1.03
North Umpqua	18	17.39	Lake Abert	2	0.61
Molalla-Pudding	21	14.31	Applegate	4	0.59
Upper Klamath Lake	11	11.68	Upper Deschutes	7	0.51
Lower Columbia-Clatskanie	12	10.84	Siltcoos	4	0.50
Siuslaw	11	10.21	Middle Columbia-Lake Wallula	1	0.47
Siletz-Yaquina	46	10.17	Upper Crooked	1	0.42
South Santiam	13	8.33	Umatilla	4	0.35
Coquille	10	6.89	Burnt	1	0.32
Upper Rogue	12	6.77	Walla Walla	1	0.32
Umpqua	14	6.62	Upper John Day	3	0.22
Nehalem	11	6.35	Lower Deschutes	1	0.12
Middle Columbia-Hood	14	5.92	Alvord Lake	1	0.08
Mckenzie	15	5.88	Summer Lake	2	0.06
Lower Rogue	7	5.81	Lower John Day	1	0.04
Lower Columbia-Sandy	15	5.60	Imnaha	1	0.02
Illinois	3	5.46	Upper Klamath	1	0.00
Lower Crooked	5	4.67	Total	1,281	1,287.28

Source: Author, data from Oregon Department of State Land (DSL) 2017
*Note that there are 28 HUC8 geographies that had no permanent wetland impacts from 2000-2016

Permanent Wetland Impacts by Year

The annual count of projects with permanent wetland impacts and the associated permanent wetland impact acreage can be seen in Table 8. From 2000-2016, a total of 1,287 acres of wetlands were permanently impacted in Oregon.

The median project impact was 0.18 acres while the mean was 1.01 acres. The distribution of project impacts has an extreme right skewed distribution. Therefore, the median impact is a more meaningful measure of central tendency than the mean. The mean is affected by the small number of large project impacts in the tail of the distribution.

Table 8: Permanent Wetland Impact Acres by Year

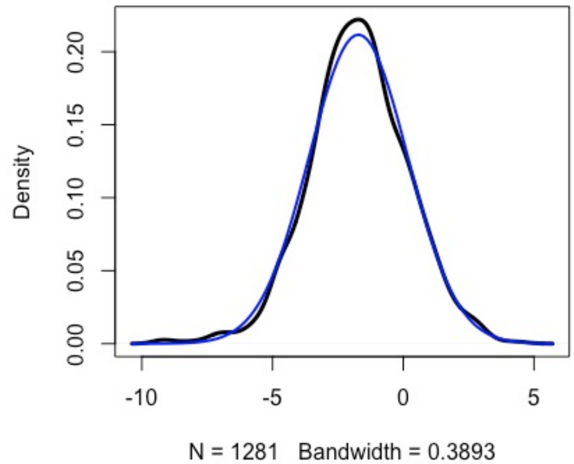
Year	# of Projects	Permanent Wetland Impact Acres	Min	Q1	Median	Mean	Q3	Max
2000	76	70.49	0.01	0.10	0.29	0.93	0.66	11.15
2001	67	76.57	0.00	0.10	0.21	1.14	0.81	14.42
2002	85	54.13	0.00	0.05	0.12	0.64	0.32	14.10
2003	98	69.35	0.00	0.07	0.26	0.71	0.65	6.18
2004	82	74.14	0.01	0.07	0.17	0.90	0.39	18.71
2005	90	118.29	0.01	0.05	0.18	1.31	0.60	58.59
2006	86	136.32	0.00	0.08	0.31	1.59	1.15	24.87
2007	94	218.29	0.00	0.07	0.24	2.32	0.92	93.62
2008	79	49.36	0.00	0.04	0.12	0.62	0.36	10.41
2009	48	31.68	0.01	0.05	0.21	0.66	0.77	4.90
2010	64	71.24	0.00	0.03	0.16	1.11	0.91	17.72
2011	58	46.26	0.00	0.06	0.14	0.80	0.73	11.06
2012	61	34.18	0.00	0.03	0.10	0.56	0.32	17.98
2013	60	36.90	0.00	0.06	0.20	0.61	0.48	10.31
2014	79	119.94	0.00	0.05	0.17	1.52	0.82	36.36
2015	82	46.79	0.00	0.04	0.13	0.57	0.46	12.46
2016	72	33.34	0.00	0.04	0.11	0.46	0.44	7.10
2000-2016	1,281	1,287.28	0.00	0.05	0.18	1.01	0.61	93.62

Source: Author, data from Oregon Department of State Land (DSL) 2017

To assess if the mean impact size has significantly changed over time, it is necessary to normalize the permanent wetland impact distribution. A log transformation of the permanently impacted acres produces a roughly normal distribution (Figure 4). In this figure, the black line is the density plot of the log permanent wetland impacts, while the blue line is the normal plot of the log. There is strong conformity of the transformed data to the true normal distribution. The appropriateness of the log transformation is further confirmed by looking at the quantile-quantile (QQ) plot (Figure 5). This shows little curve or variance from the straight line that is expected if the log transformed data is truly from a normal distribution.

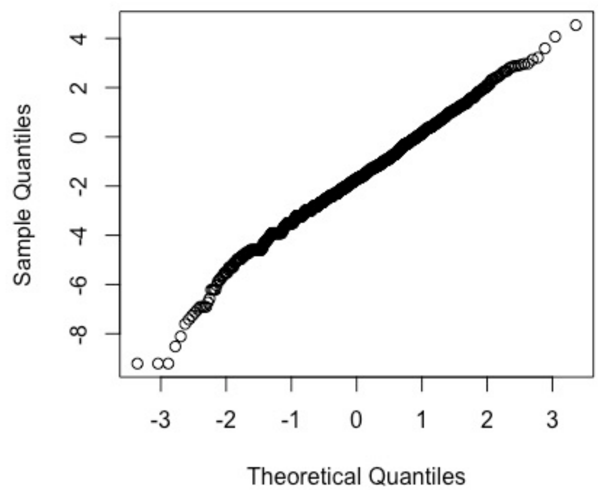
The annual boxplot of the log permanent wet impact can be seen in Figure 6. This figure indicates that the mean and variation of the log distribution have remained relatively constant from 2000-2016. This can be statistically investigated with an analyses of variance (ANOVA) test. An ANOVA test for the log of the permanent wetland impact by year results in a F value of 1.30 and a p value of 0.19. Thus, the differences between the annual mean log permanent wetland impact acreages are not statistically significant.

Figure 4: Density Plot of Log Permanent Wetland Impact vs True Normal Distribution



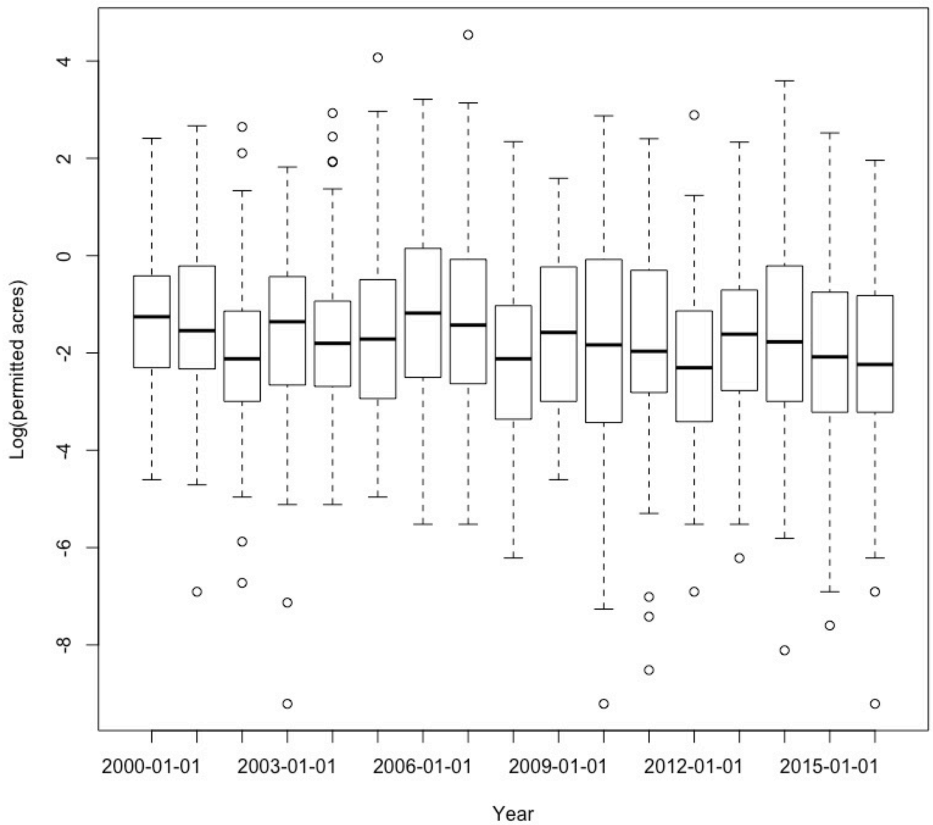
Source: Author, data from Oregon Department of State Land (DSL) 2017

Figure 5: QQ Plot of Log Permanent Wetland Impact



Source: Author, data from Oregon Department of State Land (DSL) 2017

Figure 6: Boxplot Log Permanent Wetland Impact by Year



Source: Author, data from Oregon Department of State Land (DSL) 2017

Compensatory Wetland Mitigation Transactions

Of the 1,281 projects with permanent wetland impacts, there were 121 projects that did not have associated compensatory wetland mitigation action records in the DSL database. For these records, there was a record for a permanent wetland impact, but no record for any type of compensatory action taken to offset this impact. This left 1,160 individual projects with associated compensatory wetland mitigation actions. Some projects utilized multiple types of compensation, so the columns total in Table 9 represent individual compensatory wetland transactions, not individual development projects. From 2000-2016, there were 1,534 compensatory wetland mitigation transaction from the 1,160 individual development projects.

The use of mitigation bank credits purchases was 15% or less of annual transactions from 2000-2010 and then rose sharply to 30% in 2011, and 62% in 2012. Since 2012, mitigation bank credits purchases have accounted for over 56% of annual compensatory wetland mitigation transactions. Correspondingly, there has been a notable decrease in the use wetland creation, enhancement, and restoration from 2009-2012.

Overall, from 2000-2016 mitigation bank credit purchase, wetland creation, and wetland enhancement actions each accounted for ~20% of all transactions, following by PIL at 16%, and FIL and wetland conservation each at ~1%.

Table 9: Count and Percent Compensatory Wetland Transaction Types by Year 2000-2016

Year	% of Annual Compensatory Weltand Mitigation Transactions, (count)							% Compensatory Transactions 2000-2016 (count)
	PIL	FIL	Mitigation Bank Credit Purchase	Wetland Creation	Wetland Enhancement	Wetland Restoration	Wetland Conservation	
2000	10% (10)	0% (0)	0% (0)	39% (39)	38% (38)	12% (12)	2% (2)	7% (101)
2001	11% (10)	0% (0)	1% (1)	24% (21)	39% (34)	23% (20)	2% (2)	6% (88)
2002	12% (12)	0% (0)	2% (2)	30% (31)	40% (42)	16% (17)	0% (0)	7% (104)
2003	8% (11)	1% (2)	4% (5)	38% (53)	32% (45)	17% (24)	0% (0)	9% (140)
2004	10% (11)	1% (1)	5% (6)	34% (38)	31% (35)	18% (20)	2% (2)	7% (113)
2005	23% (26)	1% (1)	3% (3)	37% (42)	25% (28)	12% (14)	0% (0)	7% (114)
2006	13% (15)	0% (0)	6% (7)	35% (41)	28% (32)	17% (20)	1% (1)	8% (116)
2007	14% (17)	0% (0)	9% (11)	35% (42)	24% (29)	16% (19)	2% (3)	8% (121)
2008	37% (28)	0% (0)	15% (11)	20% (15)	16% (12)	11% (8)	1% (1)	5% (75)
2009	30% (14)	0% (0)	13% (6)	21% (10)	17% (8)	19% (9)	0% (0)	3% (47)
2010	39% (28)	0% (0)	10% (7)	14% (10)	14% (10)	21% (15)	1% (1)	5% (71)
2011	27% (18)	9% (6)	30% (20)	16% (11)	6% (4)	9% (6)	3% (2)	4% (67)
2012	20% (13)	3% (2)	62% (40)	5% (3)	5% (3)	5% (3)	2% (1)	4% (65)
2013	15% (10)	8% (5)	56% (37)	5% (3)	6% (4)	8% (5)	3% (2)	4% (66)
2014	10% (9)	8% (7)	60% (55)	8% (7)	5% (5)	8% (7)	1% (1)	6% (91)
2015	14% (11)	6% (5)	64% (51)	1% (1)	3% (2)	13% (10)	0% (0)	5% (80)
2016	7% (5)	12% (9)	68% (51)	5% (4)	5% (4)	3% (2)	0% (0)	5% (75)
2000-2016	16% (248)	2% (38)	20% (313)	24% (371)	22% (335)	14% (211)	1% (18)	100% (1534)

Source: Author, data from Oregon Department of State Land (DSL) 2017

Compensatory Wetland Mitigation Acreage by Transaction Type

Another way of looking at the distribution of wetland compensation is by the number of acres offset by each transaction type, as opposed to the number of transactions. It is important to note that wetland creation, enhancement, restoration, and conservation mitigation does not occur at a 1:1 permanent wetland impact to compensation ratio. Minimum ratios are set be state regulations (see Compensatory Wetland Mitigation section in introduction of Report), but higher ratios may have been required on a project by project basis. The DSL database does not record the exact ratio that was utilized for each compensation action. Thus, the permanent wetland impact acres of a project and the total acres of compensation with wetland creation, enhancement, restoration, and conservation mitigation are used may not be equal even when the minimum compensation ratio is corrected for. The following table shows the seven approved mitigation types and their annual acreage of compensated wetlands.

Table 10: Compensatory Wetland Transaction Acreage by Types by Year 2000-2016

Year	PIL Acres	FIL Acres	Mitigation Bank Credit Purchase Acres	Wetland Creation Acres	Wetland Enhancement Acres	Wetland Restoration Acres	Wetland Conservation Acres
2000	1.58	0.00	0.00	40.79	114.92	11.07	22.93
2001	2.94	0.00	0.16	39.14	95.50	15.37	3.92
2002	0.89	0.00	3.67	20.13	68.72	13.21	0.00
2003	0.44	1.51	2.08	54.94	62.08	13.35	0.00
2004	0.66	0.80	1.10	15.43	284.26	33.44	4.76
2005	2.86	0.83	1.31	95.39	99.27	32.62	0.00
2006	4.06	0.00	2.91	56.37	125.04	39.41	1.67
2007	1.42	0.00	19.12	35.48	105.32	120.53	5.49
2008	2.03	0.00	7.69	36.94	49.84	6.90	0.21
2009	1.00	0.00	6.51	11.80	66.04	4.97	0.00
2010	5.37	0.00	9.66	24.34	56.95	13.96	34.46
2011	1.27	1.85	19.61	8.21	45.01	4.49	47.50
2012	0.78	0.09	33.30	1.52	2.81	0.71	1.70
2013	0.75	1.55	32.76	3.59	3.01	4.33	3.51
2014	0.50	3.41	63.56	49.35	65.83	12.11	4.35
2015	0.88	2.22	40.05	0.65	3.50	3.36	0.00
2016	0.26	2.26	21.70	5.23	1.38	4.72	0.00
2000-2016	27.68	14.51	265.18	499.30	1249.47	334.54	130.51

Source: Author, data from Oregon Department of State Land (DSL) 2017

Non-Permittee Responsible Compensatory Wetland Mitigation Actions 2000-2016

Wetland Mitigation Bank Credit Transactions

There were 313 individual projects that purchased mitigation bank credits from 29 different wetland mitigation banks from 2000-2016. Some projects purchased migration bank credits from multiple banks for a total of 346 wetland mitigation bank credit transactions.

Two wetland mitigation bank credit purchases, totaling 5.81 acres, were missing necessary information to be associated with a distinct wetland mitigation bank and are excluded from Table 5. Wetland mitigation banks can be divided into publicly owned and privately owned banks.

Table 11: Wetland Mitigation Bank Transaction 2000-2016

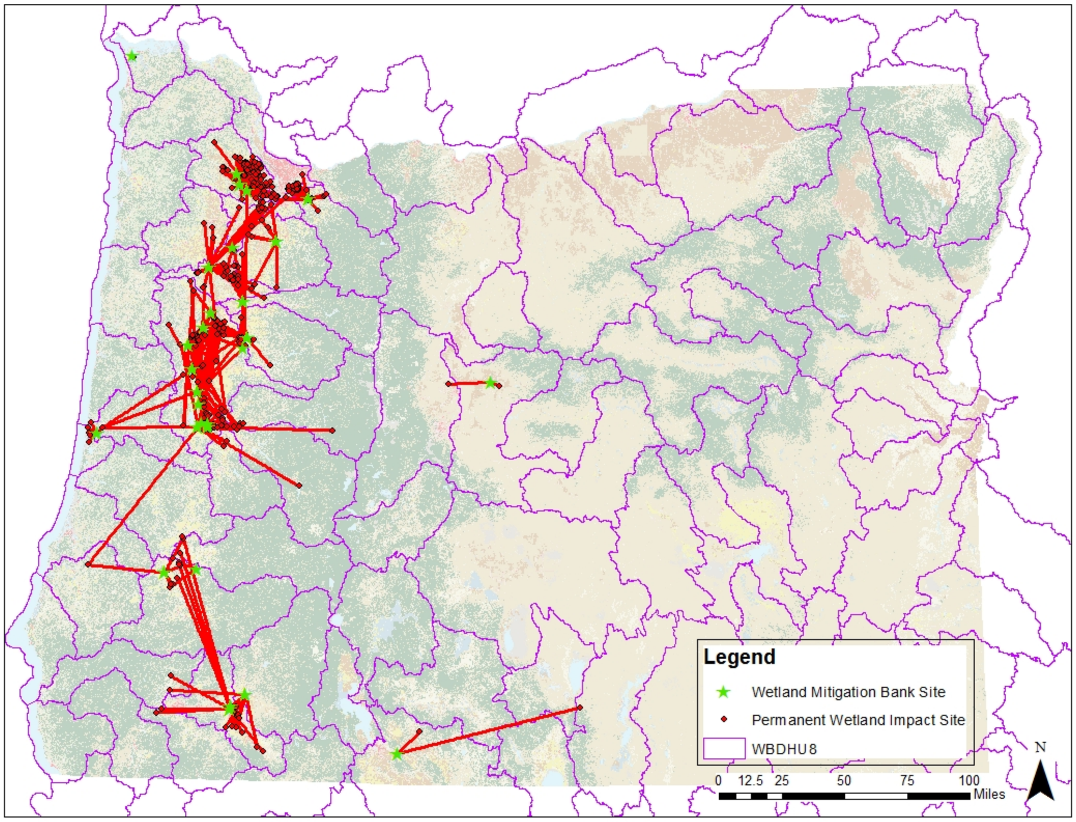
Mitigation Bank	Transactions	Total Acres	Mean Distance*
PUBLIC BANKS			
Coyote Prairie North Mitigation Bank	15	29.455	0.512
ODOT Agate Desert Vernal Pool Bank	11	10.827	0.610
ODOT Bobcat Marsh Mitigation Bank	5	1.441	0.163
ODOT Crooked River Wetland Mitigation Bank	2	0.070	0.208
ODOT Greenhill Bank	1	1.140	0.005
ODOT Lost River Bank	2	1.290	0.830
West Eugene Wetland Mitigation Bank	17	57.640	0.082
total	53	101.863	0.330
PRIVATE BANKS			
AM-City of Medford Crater Lake Ave Whetstone Creek	4	0.364	0.105
AM-Dixonville	2	4.120	0.187
AM-ODOT Martinson Ponds	4	1.300	0.109
Amazon Creek Mitigation Bank	2	2.810	0.428
Astoria Airport Mitigation Bank	1	0.930	0.011
Butler Wetland Mitigation Bank	30	8.959	0.162
Cow Hollow Wetland Mitigation Bank	7	4.604	0.194
Evergreen Wetland Mitigation Bank	12	26.585	0.322
Foster Creek Wetland Mitigation Bank	35	16.848	0.129
Frazier Creek Mitigation Bank	5	16.927	0.119
Garret-Kemnitz Wetland Mitigation Bank	8	3.051	0.215
Long Tom Mitigation Bank	23	31.874	0.313
Marion Mitigation Bank	10	11.000	0.213
Mid-Valley Wetland Mitigation Bank	6	3.840	0.225
Mud Slough Wetland Mitigation Bank	45	31.225	0.339
Muddy Creek Wetland Mitigation Bank	13	24.449	0.290
Oak Creek Mitigation Bank	1	0.170	0.364
One Horse Slough Mitigation Bank	13	39.383	0.147
Rogue Valley Mitigation Bank	8	2.940	0.224
Tualatin Valley Environmental Bank	55	12.542	0.156
Weathers Mitigation Bank	1	2.731	0.186
Wilbur Island Mitigation Bank	6	3.002	0.069
total	291	249.653	0.212
PUBLIC AND PRIVATE			
total	**344**	**351.516**	**0.234**

Source: Author, data from Oregon Department of State Land (DSL) 2017
*Mean distance from permanent wetland impact site to mitigation bank site

The mean distance from the permanent wetland impact site to the mitigation bank site is constrained by the state regulation that require mitigation bank credit sales to occur only within the predetermined service area, often the 8th unit HUC (hydrologic unit code) geography. However, the scale of these hydrologic units is highly varied, and there is significant variation in the average wetland displacement from project sites to wetland mitigation bank site. Only 14 of the 91 HUC8 sub-basins in the state of Oregon contained mitigation banks that were utilized from

2000-2016. This analysis does show that 115 times the impact site and mitigation bank are in different 8th unit HUC geographies, see Figure 7 where lines from project site to mitigation bank cross HUC geographic unit boundary.

Figure 7: Wetland Mitigation Banks and Permanent Wetland Impact Sites



Source: Author, data from Oregon Department of State Land (DSL) 2017

Permanent Wetland Impact HGM and Cowardin Classification

The permanent wetland impacts can be classified by the HGM and/or Cowardin classification of wetland that was compensated. Not all wetland compensation records had the affected HGM and/or Cowardin classification of the wetland recorded. For projects that affected different HGM and/or Cowardin, each separate compensation by HGM and/or Cowardin classification was considered a single transaction. This is a different way of classifying transactions from Table 9 and therefore Table 12 shows a different total transaction count from 2000-2016.

Table 12: Permanent Wetland Impact by HGM Class

HGM Class		Transactions	Total Acres	% of Total Acres (excluding na)
Number	Name			
2544	**Slope/Flat**	205	404.3	34.2%
2540	**Flat**	230	278.1	23.6%
2541	**Depressional**	204	196.3	16.6%
2539	**Slope**	315	156.0	13.2%
2542	**Riverine Flow-Through**	342	96.1	8.1%
2546	**Estuarine**	40	17.7	1.5%
2543	**Riverine Impounding**	68	15.9	1.3%
2545	**Lacustrine Fringe**	8	15.3	1.3%
2547	**Coastal Fringe**	8	0.9	0.1%
3058	**Estuarine Fringe Riverine**	1	0.3	0.0%
na	**na**	274	106.4	na
	total	1,695	1,287.3	100%

Source: Author, data from Oregon Department of State Land (DSL) 2017

Table 13: Permanent Wetland Impact by Cowardin Class

Cowardin Class						Transactions	Total	% of Total Acres	
Number	Abbr.	System	Subsystem	Class	Subclass		Acres	(excluding na)	
2307	PAB	Palustrine	-	Aquatic Bed	-	4	24.35	1.94%	77%
2319	PEM			Emergent	-	4	0.13	0.01%	
2310	PEM1				Persistent	1076	928.38	74.14%	
2323	PEMC				Seasonally Flooded	19	2.71	0.22%	
2655	PFO			Forested	-	1	0.01	0.00%	
2619	PFO1				Broad-Leaved Decidious	1	0.75	0.06%	
2990	POW			-	?	1	0.02	0.00%	
2954	PSS				Scrub-Shrub	1	2.38	0.19%	
2303	PUB				Unconsolidated Bottom	4	0.26	0.02%	
2315	R1	Riverine	Tidal	-	-	187	55.96	4.47%	20%
2322	R2		Lower Perenial	-	-	8	1.83	0.15%	
2591	R2AB			Aquatic Bed	-	7	0.50	0.04%	
2599	R2RB			Rock Bottom	-	4	1.53	0.12%	
2629	R2UB			Unconsolidated Bottom	-	17	97.29	7.77%	
2592	R3RB		Upper Perennial	Rock Bottom	-	2	0.27	0.02%	
2304	R3UB			Unconsolidated Bottom	-	2	0.22	0.02%	
2308	R4		Intermittent	-	-	1	0.00	0.00%	
2633	R4SB			Streambed	-	1	0.20	0.02%	
2316	REM		-	Emergent	-	4	2.83	0.23%	
2630	RFO			Forested	-	12	11.13	0.89%	
2584	ROW			?	-	1	0.17	0.01%	
2302	RSS			Scrub-Shrub	-	6	4.32	0.34%	
2312	RUB			Unconsolidated Bottom	-	160	74.43	5.94%	
2602	RUS			Unconsolidated Shore	-	2	0.42	0.03%	
2318	E1	Estuarine	Subtidal	-	-	3	0.72	0.06%	2%
2317	E1AB			Aquatic Bed	-	5	1.13	0.09%	
2628	E1UB			Unconsolidated Bottom	-	4	0.37	0.03%	
2989	E2		Intertidal	-	-	4	1.13	0.09%	
2632	E2AB			Aquatic Bed	-	2	0.09	0.01%	
2313	E2EM			Emergent	-	1	0.09	0.01%	
2987	E2EM1				Persistent	1	0.40	0.03%	
2309	E2EM2				Non-Persistent	5	17.20	1.37%	
2306	E2SS			Scrub-Shrub	-	1	0.01	0.00%	
2601	EEM		-	Emergent	-	3	0.83	0.07%	
2321	EUB			Unconsolidated Bottom	-	1	0.04	0.00%	
2948	EUS			Unconsolidated Shore	-	1	0.28	0.02%	
2301	L1OW	Lacustrine	Limnetic	?	-	5	5.29	0.42%	1%
2311	L2AB		Littoral	Aquatic Bed	-	8	9.00	0.72%	
2986	Other	-	-	-	-	9	0.71	0.06%	0%
2314	FO	-	-	Forested	-	19	4.79	0.38%	
2946	-	-	-	-	-	1	0.02	0.00%	
NA	na	-	-	-	-	97	35.10	na	na
					total	1,695	1,287.28	100%	100%

Source: Author, data from Oregon Department of State Land (DSL) 2017

Compensatory Wetland Mitigation Transaction Types by HGM Class

The distribution of wetland transactions types by HGM wetland classification can be seen in the following table. The sample size for the three least common HGM classifications (Lacustrine Fringe, Estuarine, and Coastal Fringe) are quite small and variations in the mitigation type used may be the result of small sample size bias.

Table 14: Compensatory Wetland Mitigation Transaction Types by HGM Class

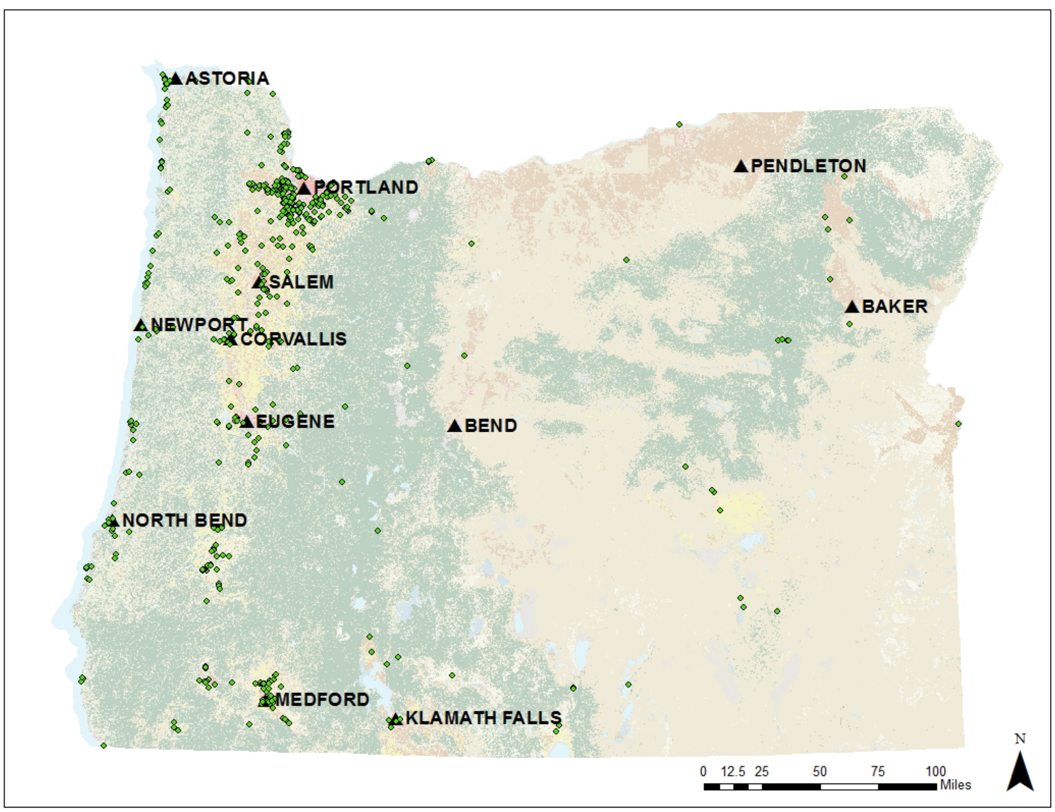
HGM	Name	% of Total Acerage per HGM Class							Number of HGM Transactions
		PIL	FIL	Mitigation Bank Credit Purchase	Wetland Creation	Wetland Enhancement	Wetland Restoration	Wetland Conservation	
2539	Slope	11%	6%	24%	27%	19%	11%	2%	n = 386
2540	Flat	7%	3%	25%	24%	25%	14%	2%	n = 310
2541	Depressional	12%	2%	12%	32%	22%	17%	3%	n = 316
2542	Riverine Flow-Through	16%	2%	14%	29%	24%	15%	1%	n = 477
2543	Riverine Impounding	19%	0%	10%	31%	22%	17%	0%	n = 118
2544	Slope/Flat	16%	2%	25%	25%	22%	10%	1%	n = 312
2545	Lacustrine Fringe	13%	0%	0%	33%	33%	20%	0%	n = 15
2546	Estuarine	14%	0%	2%	7%	23%	53%	0%	n = 43
2547	Coastal Fringe	0%	0%	0%	50%	25%	25%	0%	n = 8

Source: Author, data from Oregon Department of State Land (DSL) 2017

Relation of Compensatory Wetland Mitigation to ARMP Priority Conservation Lands

From 2000-2016 there were 579 distinct permittee responsible mitigation sites with compensatory wetland actions taken and 344 mitigation bank transactions at 29 wetland bank locations. The location of these mitigation actions can be seen in the following figure. The remaining compensatory wetland mitigation actions utilized non-permittee mitigation actions of PIL credits and FIL credits, and the location of projects funded through these programs is not included in this analysis. The ARMP has identified seven priority conservation lands that wetland mitigation actions may be able to be aligned with.

Figure 8: Mitigation Action Locations 2000-2016



Source: Author, data from Oregon Department of State Land (DSL) 2017

The ARMP identified seven existing conservation datasets to compare with the location of historic wetland mitigation actions. Due to time and data availability only Federal Restoration Actives and Wetlands of Conservation Concern were analyzed before the completion of this research project. Table 15 shows the number of mitigation banks and mitigation sites that fell entirely within or within a quarter mile buffer of the ARMP priority conservation lands. The quarter mile buffer is inclusive of the no buffer category, thus the number of sites only within the buffer area is the difference between the no buffer and buffer columns.

Table 15: ARMP Priority Conservation Lands and Compensatory Wetland Mitigation Sites

Data	No Buffer		Buffer = 1/4 mile	
	# of Mitigation Banks	# of Mitigation Sites	# of Mitigation Banks	# of Mitigation Sites
Critical Habitat for Aquatic Resource Dependent Species				
Oregon Watershed Restoration Inventory				
Federal Restoration Activities	1	0	1	6
Essential Salmonid Habitat				
Important Bird Areas				
Conservation Opportunity Areas				
Wetlands of Conservation Concern	9	71	13	92
total	**10**	**71**	**14**	**98**

DISCUSSION AND RECOMMENDATIONS

An analysis of historic trends in Oregon's compensatory wetland mitigation program is provided and then each of this project's three objectives are discussed. This project sought to (1) analyze the clustering of wetland loss and mitigation within regulatory watersheds; (2) analyze the relationship of wetland mitigation and the type of wetland impacted, and (3) analyze the relationship of wetland mitigation locations and ARMP defined priority conservation lands.

1. What are general temporal and geographic patterns and trends in Oregon's compensatory wetland mitigation program?

Stable Permanent Impact Size

The annual mean permanent wetland impact acreage per project did not significantly differ during 2000-2016 (f=1.3, df=16, p=0.19). This indicates that the amount of wetland acres impacted on a project-by-project basis has remained relatively stable during the period of the study. This suggests that while changes in construction practices and variations in economic activity have influenced the annual number of projects with permanent wetland impact, the amount of wetland impacted per project has not significantly changed.

RECCOMENDATION

The log mean impact size provides a trackable metric for the ARMP. While wetland compensatory mitigation regulations have only a limited effect on the number of projects with permanent wetland impact, reducing the per-project impact would have clear environmental benefits. Compensatory mitigation is only allowed for *unavoidable* wetland losses and the ARMP program should look to not only better manage unavoidable losses, but should also work to reduce the need for compensatory mitigation by requiring permittees to better avoid, minimize, and rectify wetland impacts.

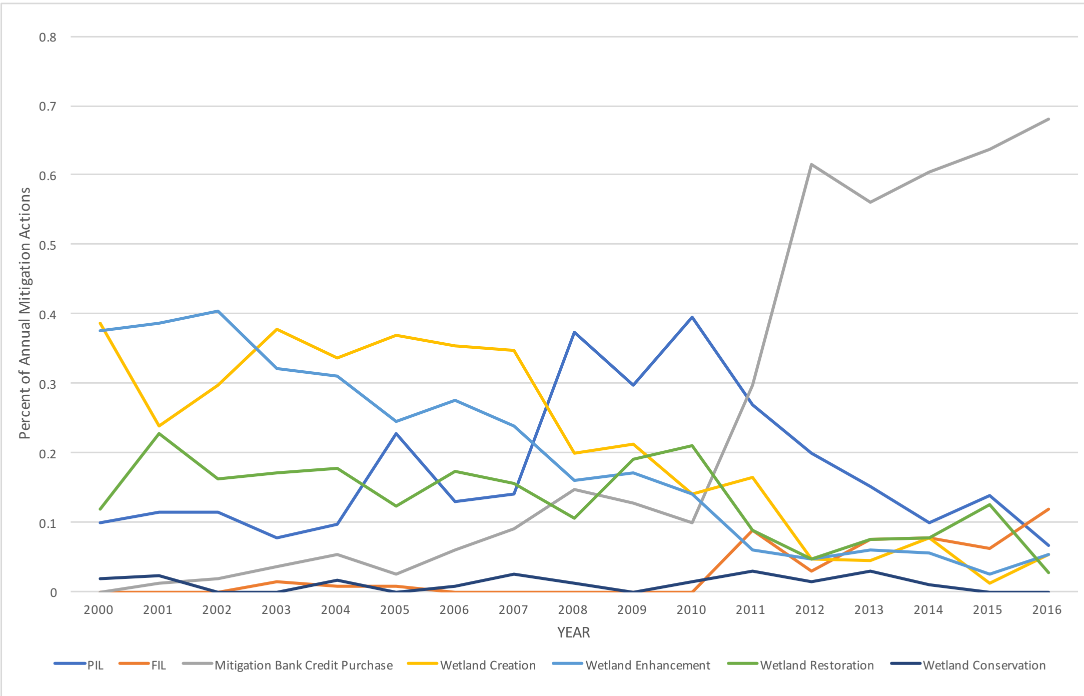
A Shift to Off-Site Mitigation though Mitigation Bank Credit Purchases

The use of non-permittee responsible off-site mitigation through the purchase of wetland mitigation bank credits has grown from 0% of annual wetland mitigation transactions in 2000 to almost 70% on transactions in 2016 (Figure 9). This reflects both policy changes and the growth of the wetland mitigation banking program in Oregon. The data show a clear transition from the use of on-site permittee responsible mitigation to off-site non-permittee responsible mitigation as evidenced by the decrease in use of permittee responsible mitigation actions and increase in the use of wetland mitigation banks.

RECCOMENDATION

Oregon's wetland mitigation policy has undergone significant change over the past 16 years. The historic analysis of shift in mitigation transaction type can be compared against changes in Oregon's wetland regulations. This can be used to assess how quickly changes in regulations resulted in changes in the type of wetland mitigation used. A detailed review of policy changes in Oregon over the past 16 years was not conducted during this project, but is an area for future research.

Figure 9: Percent of Annual Wetland Mitigation Actions by Mitigation Type



Source: Author, data from Oregon Department of State Land (DSL) 2017

Wetland Mitigation Bank Sales Across HUC8 Sub-Basin Boundaries

This project's analysis showed that 115 mitigation bank credit transactions, or 37% of mitigation bank credit sales during the study period, had the location of the permanent wetland impact and the mitigation bank utilized in different HUC8 Sub-Basins. This is concerning as studies have shown that when mitigation sites are selected outside of the affected watershed, the compensation does not contribute to maintaining the overall health of the watershed being impacted. This despite that fact that there has been no-net loss of wetland acres across the multiple watersheds.[65]

[65] Kettlewell, C.I., Bouchard, V., Porej, D. et al. (2008).

RECOMMENDATION

With the regulatory preference moving from on-site permittee responsible mitigation to non-permittee responsible off–site mitigation in a watershed context, it is increasingly critical to define ecologically based watershed units in which wetland acres and functions are preserved. As the DSL continues working to make wetland compensation decision using a watershed approach, there is a need to define, describe, and quantify watershed units' health. Such a system would allow for informed decisions to made about transferring wetland ecosystem services within, and between, watershed units.

2. What is the clustering of wetland loss and mitigation within regulatory watersheds?

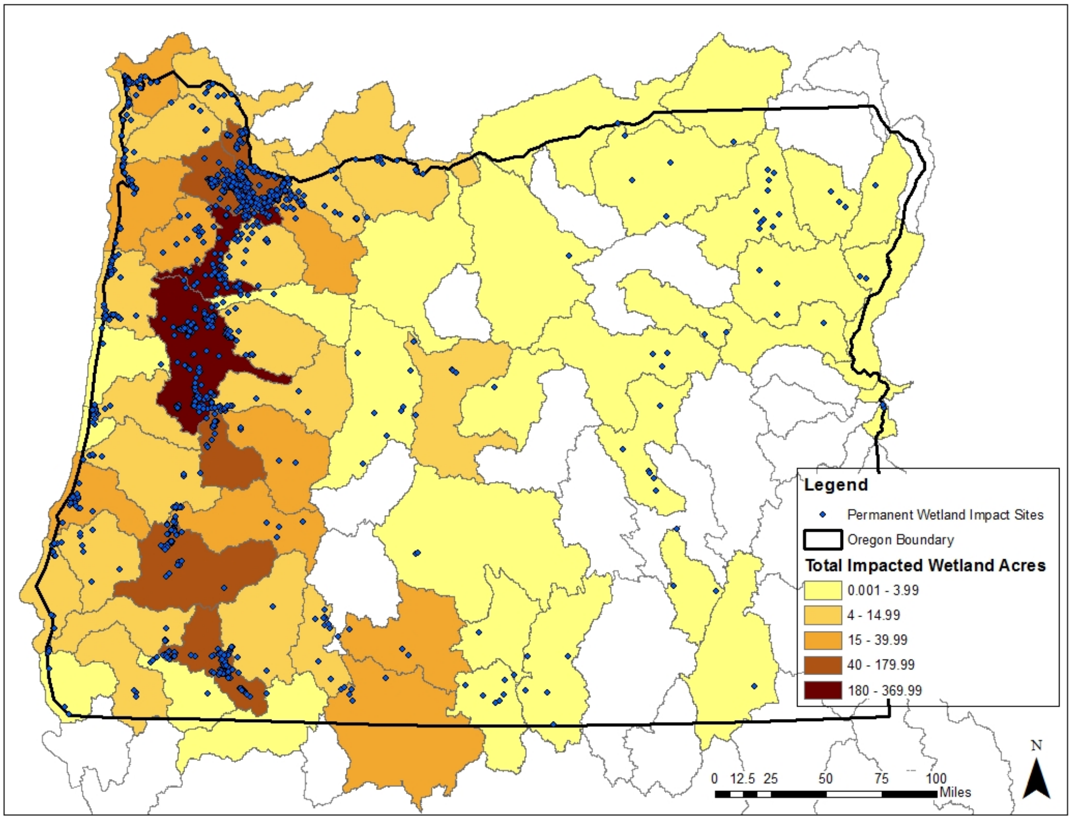
Permanent wetland impacts show significant clustering in the Willamette Basin (Figure 10) with just over 50% of permanent wetland impact acreage from 2000-2016 occurring in these three sub-basins. The largest numbers of projects with permanent wetland impacts occurred just North of the Willamette Basin in Tualatin sub-basin (Table 7). This clustering of projects with permanent wetland impacts and affected wetland acreage has significant implications for overall watershed health. Research has shown that the cumulative effects of multiple projects in the same reach of stream or watershed can be greater than the combined impact of the same projects in different watersheds.[66]

RECOMMENDATION

The significant clustering of permanent wetland impacts within the Willamette Basin has a disproportionate effect on watershed health compared to a case where these impacts were dispersed across the state. This underscores the importance of developing a watershed based approach to mitigation, specifically within the highest impact sub-basins, that addresses the fact that these are highly impacted watersheds. These sub-basins should be where the ARMP concentrates its development and expansion of a wetland functions based compensatory mitigation program within a watershed context.

[66] Bedford, B.L. (1999). Cumulative effects on wetland landscapes: Links to wetland restoration in the United States and Southern Canada. Wetlands 19(4):775–788.

Figure 10: Wetland Permanently Impacted Acres 2000-2016 by HUC8 Geography*



Source: Author, data from Oregon Department of State Land (DSL) 2017
***The white areas of the map are HUC8 geographies that had no permanent wetland impacts from 2000-2016**

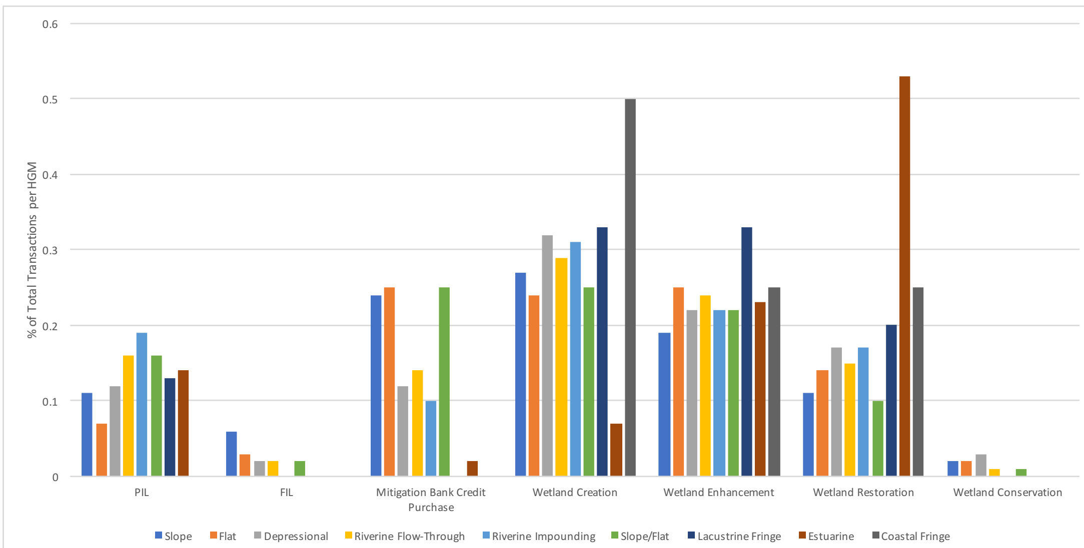
3. What is the relationship between wetland mitigation actions and the type of wetland impacted?

The type of mitigation used for each HGM wetland classification does show variation as seen in Figure 11. The lacustrine fringe, estuarine, and coastal fringe HGM classifications have very small sample sizes which may skew their distributions. Mitigation banking is twice as common for slope, flat, and slope/flat wetlands than depression, riverine-flow through, and riverine impounding wetlands. Mitigation banking was not used or was rarely used for lacustrine fringe, estuarine, and coastal fringe wetlands. For these less common affected wetland types, mitigation banking may not be financially feasible within a regulatory service area.

RECOMMENDATION

The use of HGM and Cowardin wetland classification is being increasingly supplemented with the use of the Oregon Rapid Wetland Assessment Protocol (ORWAP).[67] The use of the ORWAP is not currently tracked in the DSL database, and ORWAP Version 3.1 Manual recognizes the need for archiving the results of this assessment tool. As the ORWAP and other functional assessment tools replace the HGM and Cowardin wetland classification assessment, it will critical that this data be collected and stored such that ORWAP program can be monitored and improved. The DSL should look to track and store the ORWAP primary group functional data as part of the compensatory wetland mitigation program.

Figure 11: Compensatory Wetland Mitigation Transaction Types by HGM Class



Source: Author, data from Oregon Department of State Land (DSL) 2017

4. What is the relationship of wetland mitigation locations and ARMP defined priority conservation lands?

The historic wetland mitigation sites and wetland mitigation bank sites show some existing alignment with the Oregon Wetlands of Conservation Concern. There were nine mitigation banks and 71 mitigation actions taken within Wetland of Conservation Concern from 2000-2016. An additional four mitigation banks and 21 conservation actions occurred within a quarter mile of a Wetland of Conservation Concern. The proximity of wetland compensation action to existing conservation or protected lands is known to contribute to increasing a created, enhanced or

[67] Adamus, P., Verble, K., Rudenko, M. (2016). Manual for the Oregon Rapid Wetland Assessment Protocol (ORWAP) Version 3.1. Oregon Department of State Lands

restored wetland's success in compensating for losses by increasing its connectivity, size, and overall contributions to wetland functions in its watershed.[68]

RECOMMENDATION

The historic overlap between wetland compensation actions and Wetlands of Conservation Concern was not the result of proactive planning. As DSL continues to move to a wetland functions based compensatory mitigation program within a watershed context, there is a need to identify sites for compensation actions that can enhance and maintain watershed health. The ARMP identified priority conservation layers allow for the identification and selection of priority mitigation wetlands within watersheds that can be targeted to better contribute to the overall health and function of the watershed.

[68] National Cooperative Highway Research Program (NCHRP). (2010);

Kramer, Elizabeth A., & Carpenedo, Steven. (2009).

CONCLUSION

Wetlands are a highly important component of healthy watershed and there has been a significant loss of historic wetland coverage and associated ecosystem services since the 1800s. The development of state and federal compensatory wetland mitigation programs were developed in response to this and has made a significant contribution through the policy of no-net loss of wetland acres. With increasing attention being paid to wetland functions and ecosystem services, the Oregon ARMP is a working to use a function-based assessment within a watershed approach to quantity compensatory mitigation requirements.

The analysis of historic permanent wetland impacts and compensation highlights some of the barriers to adopting this new approach; allowance of wetland mitigation bank credit sales across sub-basins, a lack of tracking of the ORWAP results, and no proactive alignment of mitigation with priority conservation lands. As the ARMP continues to develop, the Department of State Lands should look to address these concerns.

APPENDIX A: DSL DATA READ ME FILE

From:

Dan Antonson, GIS Specialist (Questions about the GIS data, tables, or map)

Dana Hicks, Mitigation Specialist (Questions about DSL Regulatory Programs, Mitigation or Removal/Fill)

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The data, tables, and maps in this folder are a snapshot in time from the DSL Land Administration System (LAS) database. This information is subject to change and correction at any time and there are no guarantee of accuracy or completeness of this information. This product is for informational purposes and may not have been prepared for, or be suitable for legal, engineering, or surveying purposes. Users of this information should review or consult the primary data and information sources to ascertain the usability of the information.

In the LAS_RGL_request.mxd map the layers have been added and symbolized to help get started viewing the data. The primary data set to use is the RGL_Report_Sites_pts layer as this contains points that may be separated as Impact and Mitigation locations (site_name_1 containing "Mitigation" or "Mit" values).

The dbo_site_refs_app_pts and dbo_site_refs_mit_pts have a Relationship to the LAS_RGL_GainsLoss_Report table, see set up with the "Related Tables" button the attribute table for these 2 layers. The LAS_RGL_GainsLoss_Report table is then related to the RGL_Report_Sites_pts layer. These Relationship connections can then be used to see the related records for any given RF Application or LAS_RGL_GainsLoss_Report record or RGL_Report_Sites_pts.

The 5 Feature Classes in this database are the following:

dbo_site_refs_pts:

These points represent all of the locations identified in the LAS database that are associated in some way with a DSL record of Regulatory or Proprietary (Land/Ownership Management) activities. To this point data is attached the records for Applications in LAS, a review will reveal "Regulatory" and "Proprietary" records under the field "auth_category_name". The "Regulatory" records include the Removal/Fill records. (102,634 point features)

dbo_site_refs_app_pts:

These points are just those from the first data set that are related to a DSL Application for Regulatory or Proprietary programs (46,233 point features with "parent_table" = "authorization_application"). In the Layer File "Reg_R-F_App_pts.lyr" this set is restricted by the date Jan. 1, 2000 (see Definition Query tab) and then Joined to LAS_RGL_wApp table to restrict it further to only those Regulatory records with a related RGL record (3614 point features, see "Joins & Relates" tab).

dbo_site_refs_mit_pts:

These points are just those from the first data set that are related to an RGL record that are not part of a DSL Application (7,940 point features with "parent_table" = "mitigation_project"). In the Layer File "Reg_R-F_Mit_pts.lyr" this set is restricted by Joining to LAS_RGL_woApp table to restrict it to only those records with a related RGL record (246 point features).

MitigationBanks_pts:

These points represent the location of Wetland Mitigation Banks. These are developed from a combination of Mitigation Bank records and the associated Site record in the LAS database.

RGL_Report_Sites_pts:

These points represent all locations referenced by records in the RGL_GainsLoss_Report table. This table contains impact and mitigation notes within the Site_Name_1 field. This may be sufficient to identify Impact locations versus Mitigation locations.

The tables in the Esri File Geodatabase "RGL_Since2000.gdb" are the raw export from the LAS database and are used as source data for the layers seen in the GIS map.

For DSL reference, the LAS_RGL_Export table is developed from a LAS Query through the following process:

1. A. In LAS Select "RGL Project"

B. Select "Query RGL Projects"

C. Query base on RGL Project Type for "a-Permit (compensatory)" and "b-Unauthorized (compensatory)"

D. Select "File", then "Export"

E. In pop-up box, select "Excel8...with headers" and named "LAS_RGL_Export.xls"

2. A. In LAS Select "RGL Project"

B. Select "Query Gains/Losses"

C. Query base on RGL Project Type for "a-Permit (compensatory)" and "b-Unauthorized (compensatory)"

D. Select "File", then "Export"

E. In pop-up box, select "Excel8...with headers" and named "LAS_RGL_GainsLossReport.xls"

The LAS_RGL_Export table was split into 2 tables; one for Resource Gains/Losses (RGL) records that have a related Removal/Fill (RF) record (Applications or Apps) and one for RGL records that do not have RF records, named LAS_RGL_wApp and LAS_RGL_woApp, respectively. This was done based on the presence or absence of a numerical value in the field "application_id", the presenece of a number representing an associated Removal/Fill record.

Analysis Summary Tables

The following annotated R Markdown script was written to create the two summary tables; 1. Projects with Permanent Wetland Impacts 2000-2016 and 2. Compensatory Wetland Mitigation Transactions 2000-2016.

Table 1: Projects with Permanent Wetland Impacts 2000-2016

Step 1: Restrict Permanent Wetland Impact Records to 2000-2016

The dbo_site_refs_app_pts are geocoded and the table contains a date field that is restricted to 2000-2016, but the records are not restricted to projects with permanent wetland impacts. The RGL_Report_Sites is geocoded and the table contains only project with permanent wetland impacts, but it is not restricted to 2000-2016. A spatial intersection of these two tables results in a geocoded table of permanent wetland impact records restricted to 2000-2016.

```
RGL_Report_Sites_INTERSECTION_dbo_site_refs_app_pts <- merge(x = RG
L_Report_Sites, y = dbo_site_refs_app_pts, by.x = c('latitude', 'lo
ngitude'), by.y =c('dbo_site_refs_app_pts.latitude', 'dbo_site_refs
_app_pts.longitude'))
```

The RGL_Report_Sites_INTERSECTION_dbo_site_refs_app_pts contains columns that are not of interest, and the unneeded ones are dropped. Project issue date, location, and the LAS_RGL_wApp_mitigation_id fields are kept.

```
Date_Location_Mitigation_ID <- subset(RGL_Report_Sites_INTERSECTION
_dbo_site_refs_app_pts, select= c(40,47,70,71,76))
```

Step 2: Retain Single Row for Each Unique Project

The RGL_Report_Sites_INTERSECTION_dbo_site_refs_app_pts contains multiple row for individual projects when the project has multiple wetland impacts and/or multiple mitigation actions taken. The table is collapsed on the LAS_RGL_wApp_mitigation_id field such that each row has a unique LAS_RGL_wApp_mitigation_id while retaining the project location and date fields.

```
Date_Location_Mitigation_ID_Collapsed <- Date_Location_Mitigation_
ID[ !duplicated(Date_Location_Mitigation_ID$LAS_RGL_wApp_mitigation
_id), ]
```

Date_Location_Mitigation_ID_Collapsed has 1629 rows with each having a unique LAS_RGL_wApp_mitigation_id, an associated geographic position (latitude, longitude), and the project issue date.

Step 3: Find Permanent Wetland Impact Acreage

To attach the permanent wetland impact acreage associated with each unique project, the permanent wetland impacts needs to be extracted from the RGL_GainsLoss_Report table.

The RGL_GainsLoss_Report table type_name and abbreviation field can be used to select out only parent_id values that are associated with Permanent Wetland Impacts.

First, select all permanent wetland impact records from the RGL_GainsLoss_Report for all years.

```
Permanent_Wetland_Impact_Sites <- subset(RGL_GainsLoss_Report,
abbreviation == 'PM  WT IMP')
```

Next, for each parent_id there may be multiple records if the permanent wetland impact affected different HGM or Cowardin classifications of wetlands. Aggregating the Permanent_Wetland_Impact_Site on the parent_id and summing the permitted acres gives a single row for each parent_id with the aggregate permanent wetland impact acreage.

```
Wetland_Impact_Sites_Aggregated <- aggregate(permitted_acres ~
parent_id, FUN = sum, data = Permanent_Wetland_Impact_Sites)
```

This returns 2,269 rows each having an unique parent_id and aggregated permanent wetland impact acreage, but this is not restricted to 2000-2016.

Step 4: Attach Permanent Wetland Impact Acreage

The Wetland_Impact_Sites_Aggregated is joined to the Date_Location_Mitigation_ID_Collapsed retaining only rows from the later table using the all.x=true condition. This attaches the aggregate permanent wetland impact to each unique project from 2000-2016.

```
Date_Location_Mitigation_ID_Acres <- merge(x = Date_Location_Mitiga
tion_ID_Collapsed, y = Wetland_Impact_Sites_Aggregated, by.x=c("LAS
_RGL_wApp_mitigation_id"), by.y=c("parent_id"), all.x = TRUE)
```

Step 5: Remove Projects with No Impact or That Did Not Occur

Four project id (1679, 2807, 3128, and 5365) show permanent wetland impacts of 0 acres and were removed.

```
Date_Location_Mitigation_ID_Acres_Final <-
Date_Location_Mitigation_ID_Acres_Final[ !
Date_Location_Mitigation_ID_Acres_Final$LAS_RGL_wApp_mitigati
on_id %in% c(1679, 2807, 3128,5365), ]
```

In Permanent_Wetland_Impact_Sites$impact_comments like "Project never started" and "Project not implemented" should be excluded from analysis as they did not actually occur.

This creates a table of the parent_id and impact_comment. From this the parent_id of concerns can be identified and removed from Date_Location_Mitigation_ID_Acres_Final.

```
Impact_Comment <- subset(Permanent_Wetland_Impact_Sites, select = c
(6,20))
```

A subset is used to select only rows that have impact comments that indicate the project did not actually occur. A manual review of project comments was used to develop the list of terms used to identify parent_id for removal, the list was then checked for incorrectly identified projects.

```
Parent_ID_for_Removal_1 <- Impact_Comment[grep("never",
Impact_Comment$impact_comment), ]
Parent_ID_for_Removal_2 <- Impact_Comment[grep("not started",
Impact_Comment$impact_comment), ]
Parent_ID_for_Removal_3 <- Impact_Comment[grep("not implemented",
Impact_Comment$impact_comment), ]
Parent_ID_for_Removal_4 <- Impact_Comment[grep("not conducted",
Impact_Comment$impact_comment), ]
Parent_ID_for_Removal_5 <- Impact_Comment[grep("no impact",
Impact_Comment$impact_comment), ]

Parent_ID_for_Removal_All <- rbind(Parent_ID_for_Removal_1, Parent_
ID_for_Removal_2, Parent_ID_for_Removal_3, Parent_ID_for_Removal_4,
Parent_ID_for_Removal_5)
```

The parent_id from Project_ID_for_Removal_All need to be removed from Date_Location_Mitigation_ID_Acres_Final.

```
Date_Location_Mitigation_ID_Acres_Final <- Date_Location_Mitigation
_ID_Acres_Final[ ! Date_Location_Mitigation_ID_Acres_Final$LAS_RGL_
wApp_mitigation_id %in% c(Parent_ID_for_Removal_All$parent_id), ]
```

This results in 1281 rows each with distinct parent_id that occurred from 2000-2016 and had a permanent wetland impact that occurred and was more than 0 acres.

Step 6: Attach Permanent Wetland Impact Compensation Used

There are 7 different ways that permanent wetland impacts can be compensated for:

1. Payment in Lieu (PIL) Compensation
2. Fee in Lieu (FIL) Compensation
3. Mitigation Bank Credit Purchase Compensation
4. Wetland Creation Compensation
5. Wetland Enhancement Compensation
6. Wetland Restoration Compensation
7. Wetland Conservation Compensation

For each parent_id, the Date_Location_Mitigation_ID_Acres_Final has a single row with the project location and the total impacted acres. Data from the

RGL_GainsLoss_Report can be used to add columns for each of the compensation methods.

1. Look at PIL Compensation

Select 'PILCREDPUR' records and select the columns of interest.

```
PIL_Mitigation <- subset(RGL_GainsLoss_Report, abbreviation == 'PIL
CREDPUR')
PIL_Mitigation_Small <- subset(PIL_Mitigation, select=c(6,8,9,10,11
,13,25))
```

Condense subset to indicate which parent_id is associated with PIL and how many acres this mitigation totals.

```
PIL_Mitigation_Parent_ID <- subset(PIL_Mitigation_Small, select=c(1
,6))
PIL_Mitigation_Parent_ID_Aggregated <- aggregate(permitted_acres ~
parent_id, FUN = sum, data =  PIL_Mitigation_Parent_ID)
```

Rename permitted acres to refer to PIL mitigation actions

```
names(PIL_Mitigation_Parent_ID_Aggregated)[names(PIL_Mitigation_Par
ent_ID_Aggregated)=="permitted_acres"] <- "PIL_permitted_acres"
```

Merge with Wetland_Impact_and_Compensation.

```
Wetland_Impact_and_Compensation <- merge(x = Date_Location_Mitigati
on_ID_Acres_Final, y = PIL_Mitigation_Parent_ID_Aggregated, by.x=c(
"LAS_RGL_wApp_mitigation_id"), by.y=c("parent_id"), all.x = TRUE)
```

2. Look at FIL Compensation

Select 'FILCREDPUR' records and select the columns of interest.

```
FIL_Mitigation <- subset(RGL_GainsLoss_Report, abbreviation == 'FIL
CREDPUR')
FIL_Mitigation_Small <- subset(FIL_Mitigation, select=c(6,8,9,10,11
,13,25))
```

Condense subset to indicate which parent_id is associated with PIL and how many acres this mitigation totals.

```
FIL_Mitigation_Parent_ID <- subset(FIL_Mitigation_Small, select=c(1
,6))
FIL_Mitigation_Parent_ID_Aggregated <- aggregate(permitted_acres ~
parent_id, FUN = sum, data =  FIL_Mitigation_Parent_ID)
```

Rename permitted acres to refer to FIL mitigation actions.

```
names(FIL_Mitigation_Parent_ID_Aggregated)[names(FIL_Mitigation_Par
ent_ID_Aggregated)=="permitted_acres"] <- "FIL_permitted_acres"
```

Merge with Wetland_Impact_and_Compensation.

```
Wetland_Impact_and_Compensation <- merge(x = Wetland_Impact_and_Com
pensation, y = FIL_Mitigation_Parent_ID_Aggregated, by.x=c("LAS_RGL
_wApp_mitigation_id"), by.y=c("parent_id"), all.x = TRUE)
```

3. Look at Mitigation Bank Credit Purchase Compensation

Select 'MBCREDPUR' records and select the columns of interest.

```
Mitigation_Bank_Credit_Purchases <- subset(RGL_GainsLoss_Report, ab
breviation == 'MBCREDPUR')
```

Condense subset to indicate which parent_id is associated with MBCREPUR and how many acres this mitigation totals.

```
Mitigation_Bank_Credit_Purchases_Mitigation_Small <- subset(Mitigat
ion_Bank_Credit_Purchases, select=c(6,13,25))
Mitigation_Bank_Credit_Purchases_Mitigation_Parent_ID <- subset(Mit
igation_Bank_Credit_Purchases_Mitigation_Small, select=c(1,2))
Mitigation_Bank_Credit_Purchases_Mitigation_Parent_ID_Aggregated <-
aggregate(permitted_acres ~ parent_id, FUN = sum, data =  Mitigatio
n_Bank_Credit_Purchases_Mitigation_Parent_ID)
```

Rename permitted acres to refer to MBCREDPUR mitigation actions.

```
names(Mitigation_Bank_Credit_Purchases_Mitigation_Parent_ID_Aggrega
ted)[names(Mitigation_Bank_Credit_Purchases_Mitigation_Parent_ID_Ag
gregated)=="permitted_acres"] <- "MBCREDPUR_permitted_acres"
```

Merge with Wetland_Impact_and_Compensation.

```
Wetland_Impact_and_Compensation <- merge(x = Wetland_Impact_and_Com
pensation, y = Mitigation_Bank_Credit_Purchases_Mitigation_Parent_I
D_Aggregated, by.x=c("LAS_RGL_wApp_mitigation_id"), by.y=c("parent_
id"), all.x = TRUE)
```

4. Look at Wetland Creation Actions

Select "WET CREATE" records and select the columns of interest.

```
WET_CREATE_Mitigation <- subset(RGL_GainsLoss_Report, abbreviation
== 'WET CREATE')
WET_CREATE_Mitigation_Small <- subset(WET_CREATE_Mitigation, select
=c(6,8,9,10,11,13,25))
WET_CREATE_Mitigation_Parent_ID <- subset(WET_CREATE_Mitigation_Sma
ll, select=c(1,6))
```

Condense subset to indicate which parent_id is associated with MBCREPUR and how many acres this mitigation totals.

```
WET_CREATE_Mitigation_Parent_ID_Aggregated <- aggregate(permitted_a
cres ~ parent_id, FUN = sum, data =  WET_CREATE_Mitigation_Parent_I
D)
```

Rename "permitted acres"" to refer to site mitigation actions.

```
names(WET_CREATE_Mitigation_Parent_ID_Aggregated)[names(WET_CREATE_
Mitigation_Parent_ID_Aggregated)=="permitted_acres"] <- "WET_CREATE
_permitted_acres"
```

Merge with Wetland_Impact_and_Compensation.

```
Wetland_Impact_and_Compensation <- merge(x = Wetland_Impact_and_Com
pensation, y = WET_CREATE_Mitigation_Parent_ID_Aggregated, by.x=c("
LAS_RGL_wApp_mitigation_id"), by.y=c("parent_id"), all.x = TRUE)
```

5. Look at Wetland Enhancement Compensation

Select 'WET EHNANC' records.

```
Wetland_Enhancement_Mitigation <- subset(RGL_GainsLoss_Report, abbr
eviation == 'WET EHNANC')
```

Condense subset to indicate which parent_id is associated with WET EHNANC and how many acres this mitigation totals.

```
Wetland_Enhancement_Mitigation_Small <- subset(Wetland_Enhancement_
Mitigation, select=c(6,8,9,10,11,13,25))
Wetland_Enhancement_Mitigation_Parent_ID <- subset(Wetland_Enhancem
ent_Mitigation_Small, select=c(1,6))
Wetland_Enhancement_Mitigation_Parent_ID_Aggregated <- aggregate(pe
rmitted_acres ~ parent_id, FUN = sum, data =  Wetland_Enhancement_M
itigation_Parent_ID)
```

Rename permitted acres to refer to MBCREDPUR mitigation actions.

```
names(Wetland_Enhancement_Mitigation_Parent_ID_Aggregated)[names(We
tland_Enhancement_Mitigation_Parent_ID_Aggregated) == "permitted_ac
res"] <- "WET_EHNANC_permitted_acres"
```

Merge with Wetland_Impact_and_Compensation.

```
Wetland_Impact_and_Compensation <- merge(x = Wetland_Impact_and_Com
pensation, y = Wetland_Enhancement_Mitigation_Parent_ID_Aggregated,
by.x=c("LAS_RGL_wApp_mitigation_id"), by.y=c("parent_id"), all.x =
TRUE)
```

6. Look at Wetland Restoration Compensation

Select 'WET REST' records and select the columns of interest.

```
WET_REST_Mitigation <- subset(RGL_GainsLoss_Report, abbreviation ==
'WET REST.')
WET_REST_Mitigation_Small <- subset(WET_REST_Mitigation, select=c(6
,8,9,10,11,13,25))
```

Condense subset to indicate which parent_id is associated with WET REST and how many acres this mitigation totals.

```
WET_REST_Mitigation_Parent_ID <- subset(WET_REST_Mitigation_Small,
select=c(1,6))
```

```r
WET_REST_Mitigation_Parent_ID_Aggregated <- aggregate(permitted_acr
es ~ parent_id, FUN = sum, data =  WET_REST_Mitigation_Parent_ID)
```

Rename permitted acres to refer to WET REST mitigation actions.

```r
names(WET_REST_Mitigation_Parent_ID_Aggregated)[names(WET_REST_Miti
gation_Parent_ID_Aggregated)=="permitted_acres"] <- "WET_REST_permi
tted_acres"
```

Merge with Wetland_Impact_and_Compensation.

```r
Wetland_Impact_and_Compensation <- merge(x = Wetland_Impact_and_Com
pensation, y = WET_REST_Mitigation_Parent_ID_Aggregated, by.x=c("LA
S_RGL_wApp_mitigation_id"), by.y=c("parent_id"), all.x = TRUE)
```

7. Look at Wetland Conservation Compensation

Select 'WET_CONSER' records and select the columns of interest.

```r
WET_CONSER_Mitigation <- subset(RGL_GainsLoss_Report, abbreviation
== 'WET CONSER')
WET_CONSER_Mitigation_Small <- subset(WET_CONSER_Mitigation, select
=c(6,8,9,10,11,13,25))
```

Condense subset to indicate which parent_id is associated with PIL and how many acres this mitigation totals.

```r
WET_CONSER_Mitigation_Parent_ID <- subset(WET_CONSER_Mitigation_Sma
ll, select=c(1,6))
WET_CONSER_Mitigation_Parent_ID_Aggregated <- aggregate(permitted_a
cres ~ parent_id, FUN = sum, data =  WET_CONSER_Mitigation_Parent_I
D)
```

Rename permitted acres to refer to WET CONSER mitigation actions.

```r
names(WET_CONSER_Mitigation_Parent_ID_Aggregated)[names(WET_CONSER_
Mitigation_Parent_ID_Aggregated)=="permitted_acres"] <- "WET_CONSER
_permitted_acres"
```

Merge with Wetland_Impact_and_Compensation.

```r
Wetland_Impact_and_Compensation <- merge(x = Wetland_Impact_and_Com
pensation, y = WET_CONSER_Mitigation_Parent_ID_Aggregated, by.x=c("
LAS_RGL_wApp_mitigation_id"), by.y=c("parent_id"), all.x = TRUE)
```

Table 2: Compensatory Wetland Mitigation Transactions 2000-2016

Step 1: Select Permanent Wetland Impact Records

The RGL_GainLoss_Report contains the permanent wetland impact records and associated Cowardin and/or HGM classification. First these records are subsetted.

```r
Permanent_Wetland_Impact_Sites <- subset(RGL_GainsLoss_Report,
abbreviation == 'PM  WT IMP'
```

The table is then restricted to the columns of interest.

```
Permanent_Wetland_Impact_Sites_Small <- subset(Permanent_Wetland_Impact_Sites, select = c(6,8,10,13,20))
```

Step 2: Restrict Records to 2000-2016

Permanent_Wetland_Impact_Sites_Small is not restricted to 2000-2016. To restrict this to the timeframe of interest the table is merged with the Date_Location_Mitigation_ID_Acres_Final table that contains the unique project identifiers restricted to 2000-2016.

```
Permanent_Wetland_Impact_Sites_Class <- merge(x=Date_Location_Mitigation_ID_Acres_Final, y=Permanent_Wetland_Impact_Sites_Small, by.x=c("LAS_RGL_wApp_mitigation_id"), by.y=c("parent_id"))
```

Restrict to columns of interest.

```
Permanent_Wetland_Impact_Sites_Class_Merge <- subset(Permanent_Wetland_Impact_Sites_Class, select = c(1,8,9))
```

Step 3: Join HGM and Cowardin Records to Table 1

The HGM and Cowardin records associated with each unique project from 2000-2016 is finally joined to Table 1 using an inner join that retains all records from both tables

```
Permanent_Wetland_Impact_Compensation_Type_HGM_Cowardin <- merge(x=Wetland_Impact_and_Compensation, y=Permanent_Wetland_Impact_Sites_Class_Merge, by.x=c("LAS_RGL_wApp_mitigation_id"), by.y=c("LAS_RGL_wApp_mitigation_id"))
```