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Temporary Impacts to Wetlands in the Arid Southwestern United States Permitted by Section 404 of the Clean Water Act

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Temporary Impacts to Wetlands in the Arid Southwestern United States Permitted by Section 404 of the Clean Water Act

A dissertation submitted in partial satisfaction of the
requirements for the degree of
Doctor of Environmental Science and Engineering

by

Amanda Julia Zhang Wagner

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ABSTRACT OF THE DISSERTATION

Temporary Impacts to Wetlands in the Arid Southwestern United States Permitted by Section 404 of the Clean Water Act

by

Amanda Julia Zhang Wagner

Doctor of Environmental Science and Engineering

University of California, Los Angeles, 2021

Professor Richard F. Ambrose, Chair

Wetlands around the world are under threat from habitat destruction and degradation. In the United States, the Clean Water Act is the primary tool used to regulate impacts to wetlands. The U.S. Army Corps of Engineers (USACE) regulates Section 404 of the CWA, which allows for impacts to wetlands with appropriate compensatory mitigation. While permanent impacts and compensatory mitigation have been studied by researchers, temporary impacts to wetlands have not been examined. Temporary impacts to wetlands include any activity that temporarily discharges material into a wetland such as building a temporary access road, temporary water diversions, or excavating within a wetland to replace a pipe. This dissertation examines the nature, extent, and location of temporary impacts to wetlands in the southwestern United States and whether they are recovering to pre-construction conditions. First, we showed that hundreds to thousands of temporary impacts to wetlands are authorized each year within our study area of the Los Angeles District of USACE. Within our permit sampling, most (50%) of the temporary impacts were associated with construction activities, followed by sediment removal (17%). Nearly all sampled permits had a condition associated with the permit to restore the temporary impact to pre-project conditions, but only 20% were required to monitor the restoration of the temporary impact. Next, we used high resolution aerial imagery to assess hydrologic and vegetation recovery from temporary impacts from permits authorized in 2011. Vegetation cover of the impact site did not recover to 100% of pre-impact levels in 40% of our dataset. The overall riparian area recovery varied depending on the metric. From our analysis of 56 projects, four of the six metrics used had at least one site never recover and several sites that only slightly recovered. Sites with temporary impacts that never recover would be permanent rather than temporary impacts to wetlands. Finally, we analyzed permits from the past ten years for the land cover types in which the projects occurred. Between 63% and 74% of temporary impacts to wetlands were in natural lands and were individually small in impact size. We also specifically examined long, linear projects, which accounted for a disproportionate number of the impacts to wetlands in natural lands, but they were very small in total hectares. Given the hundreds to thousands of temporary impacts to wetlands permitted in this region each year, that 40% of our dataset did not fully recover vegetation cover, and only 20% of permits in our study had conditions to monitor the recovery of the temporary impacts, the USACE should update its regulations. Specifically, they should define how long an impact can occur while still being considered temporary, increase required monitoring of temporary impacts, and treat temporary

impacts as permanent if they do not fully recover, requiring the necessary compensatory mitigation.

The dissertation of Amanda Julia Zhang Wagner is approved.

Peggy Marie Fong

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2021

DEDICATION

This dissertation is dedicated to my husband, parents, and grandparents for their endless support and encouragement.

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DISCLAIMER

The views, conclusions, opinions, and positions expressed are my own, and do not necessarily represent the views, position or opinions of the United States, the Department of Defense, the Army, the U.S. Army Corps of Engineers, or any of their components.

CHAPTER ONE: INTRODUCTION

Wetlands, which include areas such as lakes, rivers, estuaries, marshes, and bogs, (Cowardin et al. 1979), are valuable ecosystems that provide important habitat to terrestrial, avian, and aquatic species (Jackson et al. 2001; Abell et al. 2007). They also provide value to humans by serving as recreation opportunities, coastal protection, fishery reserves, and by filtering excess nutrients and pollutants (Abell et al. 2007; Barbier et al. 2011; Kao et al. 2003; Woodward and Wui 2001). There are many definitions of wetlands used in the scientific and regulatory communities. In this dissertation we will refer to wetlands in the general sense as transitional areas between terrestrial and aquatic ecosystems (Cowardin et al. 1979).

Unfortunately, these valuable ecosystems are declining. Between 2004 and 2009 the U.S. lost 25,200 hectares of wetlands due to habitat loss and changing land use (Dahl 2011). In California alone, over 86% of historical wetlands have been lost in the past 150 years (Stein et al. 2010). In coastal regions, wetlands have been lost and/or degraded primarily due to overexploitation and habitat destruction and more recently to eutrophication (Lotze et al. 2006). Freshwater wetlands have also been depleted by overexploitation and habitat destruction, as well as water pollution, flow modification, and invasive species (Dudgeon et al. 2006). In the arid southwestern U.S., wetlands are under pressure from groundwater extraction, climate change, and invasive species (Davis et al. 2017; Haig et al. 2019). Additionally, future climate scenarios show continued loss of ecosystems including wetlands along the Pacific Coast due to habitat loss from sea level rise (Thorne et al. 2018). In Arizona, groundwater depletion has harmed riparian ecosystems by desertifying and reducing the riparian vegetation (Stromberg et al. 1996).

In the United States, the Clean Water Act (CWA) of 1972 is the primary legislation to safeguard wetlands in the country (33 U.S.C. §1251). The primary goal of the CWA is to restore and maintain the chemical, physical, and biological integrity of wetlands in the U.S. Within the CWA, Section 404 specifically regulates the discharge of dredged or fill material into waters of the U.S. Waters of the U.S. refers to a specific regulatory term that has changed with court rulings and new laws and policies (U.S. Army Corps of Engineers, 2020). This dissertation does not focus on differences in jurisdiction of various types of waters of the U.S., but we acknowledge that the definition has changed throughout the time frame of the data utilized within these chapters. Furthermore, we are using the term wetlands to describe all jurisdictional waters in a general sense. The U.S. Army Corps of Engineers (USACE) and the U.S. Environmental Protection Agency (EPA) coordinate to oversee and regulate Section 404 of the CWA. The USACE is the primary permitting agency and reviews applications, makes permit decisions, develops policies and guidance, and enforces Section 404.

The USACE issues general and standard permits for Section 404 of the CWA for any applicant, public or private (besides the USACE themselves) who has a project in which a discharge of dredged or fill material into wetlands is required. General permits cover activities causing minimal individual and cumulative environmental impacts whereas standard permits cover activities with more than minimal individual or cumulative impacts. Applicants apply for permits and the USACE reviews based on various factors, balancing the positive and negative outcomes of the project during the decision-making process. Other laws considered during the decision-making process include the Endangered Species Act and Section 106 of the National Historic Preservation Act. The USACE acts as a neutral decision maker, neither for or against any project, but reviews permit applications with an array of public interest factors in mind such as navigation, land use, economics, environmental concerns, and the needs and welfare of the people (General Regulatory Policies 1986).

A high-profile part of the USACE regulatory program is compensatory mitigation for permanent impacts to or loss of wetlands. Compensatory mitigation guidelines emphasize avoiding and minimizing impacts first, and then compensating if impacts are unavoidable (Hough and Robertson 2009). Compensatory mitigation can be done via restoration, establishment, enhancement, or preservation of a wetland. It is preferably done within the same watershed as the impacted wetland and can be a mitigation bank credit purchase, in-lieu fee credit purchase, or permittee-responsible mitigation (U.S. Army Corps of Engineers 2015). Mitigation banks and in-lieu fee programs are managed by someone other than the project proponent and sell credits to permittees to offset their impacts to wetlands. Permittee-responsible mitigation is done by the permittee themselves. All types of mitigation and the amounts required to offset the impacts to wetlands are reviewed by the USACE before the permit is approved.

Compensatory mitigation has been studied by researchers for decades to determine if mitigation is adequately offsetting impacts to wetlands and to see if the newly created or restored wetlands are performing well as high functioning ecosystems. An overview of the compensatory mitigation program two decades after it began found it to be inadequate with few examples of successful mitigation sites (Race and Fonseca 1996). Early research on compensatory mitigation in the San Francisco Bay found that most mitigation sites were not successful in reaching their objectives (Race 1985). Similar early research in Oregon and Washington found a mismatch in wetland type created vs. impacted, as well as issues with incomplete and poor data quality (Kentula et al. 1992). Similarly, in Louisiana, Alabama, and Mississippi, an analysis of permits from the mid-1980’s found a lack of specific objectives and a lack of monitoring of compensatory mitigation sites (Sifneos et al. 1992). Other studies have shown that compensatory mitigation was not adequately offsetting the loss of wetlands in a certain geographic area (Allen and Feddema 1996; Pfeifer and Kaiser 1995; Sudol and Ambrose 2002). In other regions, researchers found that the compensation was adequate in terms of hectares to offset the lost wetlands, but not in function (Holland and Kentula 1992; Ambrose et al. 2006).

More recently, after the 2008 Mitigation Rule which aimed to improve the compensatory mitigation (U.S. Army Corps of Engineers 2008), researchers have been focusing on function of mitigation wetlands. Some have found that compensatory mitigation is lagging and not adequately replacing lost wetland function (BenDor 2009). Other noted that the 5 years of monitoring are not enough, and that compensation sites decrease in compliance after the initial 5 years of monitoring (Van den Bosch and Matthews 2017). Although the 2008 Mitigation Rule and the No Net Loss policy are in effect, there are still issues in some regions with a net loss of streams due to Section 404 permitting (Duncan et al. 2018). The U.S. EPA acknowledge that not all mitigation projects succeed (Banks et al. 2014).

Although most research has focused on loss of wetlands and compensatory mitigation, little is known about the other type of impact to wetlands the USACE permits: temporary impacts. Temporary impacts to wetlands are permitted by the USACE under Section 404 of the CWA. They are defined as minor impacts to aquatic resources that occur for a short time during authorized activities wherein, after the work, the affected wetland is completely restored to pre-construction conditions (U.S. Army Corps of Engineers 2015). This could include impacts to wetlands such as temporary equipment staging or access roads, water diversion or dewatering, excavation of sediment to repair pipes below the wetland, or sediment removal in some circumstances. In California, from a subset of permits that required compensatory mitigation from 1991 – 2002, 51 acres of temporary impacts were permitted, compared with the 166 acres of permanent impacts to wetlands (Ambrose et al. 2006). Temporary impacts are not well understood, as their recovery is not reported by the USACE and it has not been researched. The little research that has been done shows that temporary water diversion in wetlands can harm insect communities by reducing the number of available habitat types for the duration of the diversion (Walters and Post 2011). Temporary impacts that are not restored to pre-construction conditions should be considered a permanent impact to wetlands.

Ideally, temporary impact recovery would resemble ecological restoration of the wetland. Restoration ecology brings together hydrology, ecology, geomorphology, and other fields with the goal of recovery of a degraded ecosystem (Palmer et al. 2016). A temporary impact permitted by Section 404 of the CWA is the degradation of the wetland ecosystem with the assumption it will quickly be returned to pre-project impacts. Therefore, the recovery of a wetland from temporary impacts should be done considering community assembly, landscape ecology, biodiversity, climate variability, and other relevant aspects of ecology. Given the decades of ecological restoration studies and practice, it should be possible to incorporate best practices into permits to ensure adequate recovery of temporary impacts to wetlands.

There is also the possibility of passive restoration, the idea that natural systems can recover from disturbances on their own. For example, a healthy stream system may adjust channel morphology naturally due to sediment redistribution after a flood event (Wohl et al. 2015). After extensive animal grazing, riparian vegetation in Utah recovered via passive restoration, or removal of the grazing livestock (Hough-Snee et al. 2013). Therefore, we could expect to see both active and passive restoration recovery in temporary impacts to wetlands.

This dissertation explored the following aspects of temporary impacts to wetlands in the arid southwestern U.S. as permitted by the USACE via Section 404 of the CWA:

- The second chapter determined the nature and extent of temporary impacts to wetlands permitted within the USACE Los Angeles District (District), which covers an area approximately from the U.S – Mexico border up to San Luis Obispo, without the San Joaquin Valley, and all of Arizona. We evaluated the full permit database and a subset of permits from 2009 – 2019 for numbers of impacts, hectares of impacts, impact type, and permit conditions associated with restoring and monitoring temporary impacts.
- The third chapter analyzed the recovery of temporary impacts to wetlands permitted within the District in 2011. We focused on the specific impact site as well as the larger riparian assessment area and used high resolution aerial imagery and the Aerial Imagery Assessment Method (AIAM) to look at metrics such as vegetation coverage, evidence of channel alteration, riparian zone width, and percent tree and shrub cover.
- The fourth chapter focused temporary impacts to wetlands in various land cover types within the District. We investigated different types of temporary impacts in different types of land cover as well as change over time from 2011, 2013, and 2016. Additionally, due to observations made during our data analysis, we separated and analyzed impacts caused by long, linear projects within the dataset.
- The fifth and final chapter syntheses the results presented in Chapters 2-4 and provides recommendations for how management of and policies about temporary impacts could be improved by the USACE.

CHAPTER TWO: THE NATURE AND EXTENT OF TEMPORARY IMPACTS TO WETLANDS IN THE ARID SOUTHWESTERN UNITED STATES PERMITTED UNDER SECTION 404 OF THE CLEAN WATER ACT

ABSTRACT

Although they have not received as much attention as permanent impacts, temporary impacts to aquatic resources permitted under Section 404 of the Clean Water Act (CWA) could represent substantial losses of aquatic resources. To determine the nature and extent of temporary impacts to wetlands in the arid southwestern U.S., we evaluated the entire permit database at the U.S. Army Corps of Engineers (USACE) Los Angeles District from 2009 to 2019. We selected a subset of permits from the database to examine the specific types of impacts that were classified as temporary and information about their restoration or mitigation. Our analysis showed that there were many temporary impacts authorized in the District each year, generally affecting more hectares of wetlands than permanent impacts. Fifty percent of temporary impacts in our subsample were associated with construction activities, followed by sediment removal (17%), bank stabilization (9%), water diversion (8%), and restoration activities (8%). While very few of the permits analyzed required compensatory mitigation for temporary impacts, 94% of them had a restoration condition associated with their permit. However, that condition was most often a general condition associated with the commonly used Nationwide Permit that instructs permittees to remove temporary fills, leaving out sediment removal impacts which may not be viewed as a temporary fill. Only 20% of permits analyzed had monitoring requirements associated with the restoration of their temporary impacts. While many permits had conditions to restore temporary impacts, given how many hectares of temporary impacts are authorized each

year, monitoring the outcome of these impacts should be better specified and required in USACE permits authorizing temporary impacts to wetlands.

INTRODUCTION

Wetlands are ecosystems where land and water meet. This includes coastal and inland areas such as marshes, rivers, lakes, and streams. Wetlands are unique environments that provide humans with ecosystem services such as consumable water, recreating opportunities, and coastal protection (Woodward and Wui 2001; Barbier et al. 2011). They provide valuable habitat for terrestrial, avian, and aquatic species (Abell et al. 2007; Jackson et al. 2001). All across the U.S. wetlands are being lost (Dahl 1990, 2011). Many wetlands are under threat or have already been lost due to human activities such as water pollution, habitat destruction, and introduction of invasive species (Lotze et al. 2006; Dudgeon et al. 2006).

In the U.S., the Clean Water Act (CWA) is the primary piece of legislation used for protecting wetlands[1]. Passed in 1972, its goal is to restore and maintain the chemical, physical, and biological integrity of the Waters of the United States (WotUS). Section 404 of the CWA is regulated primarily by the U.S. Army Corps of Engineers (USACE) Regulatory Program and includes the regulation of discharging dredged or fill material into waters of the U.S (33 U.S.C. §1251).

Over the years since the CWA was first passed, the USACE Regulatory Program has evolved in response to changing scientific knowledge and legal decisions. Entities who intend to discharge dredged or fill material into a water of the U.S. apply to the USACE for a Section 404 permit. Mitigation requirements to offset permanent impacts to wetlands have been required

[1] In this chapter we use “wetlands” as a shorthand for Waters of the U.S., not as the regulatory definition of wetlands.

since the 1970s but have changed over the years (Hough and Robertson 2009). A Mitigation Rule released in 2008 has heavily influenced the way the Regulatory Program now makes permit decisions by giving comprehensive guidelines and standards for compensatory mitigation (Robertson and Hough 2011). Compensatory mitigation is the required restoration (re-establishment or rehabilitation), establishment, enhancement, or preservation of wetlands intended to offset the impacts of a project to wetlands. This rule is intended to help reduce impacts on wetlands through Section 404 of the CWA (U.S. Army Corps of Engineers 2008).

U.S.-wide guidelines emphasize the preference hierarchy for mitigation is first to avoid and minimize impacts and then, if required, to compensate (Hough and Robertson 2009). While compensatory mitigation is frequently required to offset permanent impacts to wetlands, researchers have shown its flaws (Bronner et al. 2013; Bendor 2009). When required, compensatory mitigation appears to offset the impacted wetlands (Holland and Kentula 1992). However, some research has shown that the required mitigation is less than the allowed impacts for certain areas (Duncan et al. 2018; Kentula et al. 1992; Sudol and Ambrose 2002). Some studies have also shown that applicants follow their permitted mitigation requirements, but the mitigation projects themselves are not always in high functioning systems (Ambrose et al. 2006; Sudol and Ambrose 2002). Compensatory mitigation is generally required for permanent loss of wetlands or temporary losses of function to unique habitat (U.S. Army Corps of Engineers 2015). The Los Angeles District follows additional guidelines from the USACE South Pacific Division, the Division under which the Los Angeles District falls, which specify that mitigation occur within the watershed where the impacts occur, if possible.

Permanent impacts caused by permitting under Section 404 of the CWA and the resulting loss of wetlands has been the primary focus of researchers (Goldberg and Reiss 2016; Kelly

2001; Kentula et al. 1992; Sifneos et al.1992; Torok et al. 1996). Temporary impacts have been overlooked. Temporary impacts are defined as “minor impacts to aquatic resources that occur for a short-duration during authorized activities, wherein, following completion of the permitted work, the affected aquatic resources are completely restored to pre-construction elevations and contours, conditions and functionality” (U.S. Army Corps of Engineers 2015). Temporary impacts that are not restored and do not recover would then be considered a permanent impact to the wetland. Temporary disturbances to tidal wetlands can lead to reduced community assemblages (Kirwan et al. 2008). Some researchers have shown that if best management practices (BMPs), related to restoring hydrology disrupted by impacts to wetlands, are followed, temporary impacts to wetlands during silviculture activity recovered to pre-impact conditions (Schilling et al. 2019). All authorized temporary impacts to wetlands should be restored or recovered to pre-construction conditions, but the absence of specific studies of temporary impacts means that this assumption has not been tested.

To better understand the effect temporary impacts have on wetlands, we first need to understand what qualifies as a temporary impact for USACE Section 404 permits and how the permitting process addresses restoration of the temporary impacts. Additionally, we need to know how many temporary impacts are permitted under Section 404 of the CWA and whether they are being monitored for recovery to ensure they return to pre-project conditions.

This chapter explores the extent and permitting nature of temporary impacts authorized by the USACE in the southwestern U.S. by addressing how many hectares of temporary impacts were permitted, what kinds of temporary impacts were authorized and to whom, and accounting for permit conditions associated with restoring and monitoring temporary impacts.

METHODS

Study Area

Our study area was the entire USACE Los Angeles District, which includes all of Arizona and in California runs from the U.S. – Mexico border in San Diego up through San Luis Obispo County on the west and Mono County on the east. The District boundaries do not include the San Joaquin Valley and includes only parts of Kern, San Luis Obispo, and Mono Counties (Figure 2.1).

Data Collection

The dataset includes all permits issued in the USACE Los Angeles District (District) from 2009 to 2019 and a subset of these permits selected at stratified random for further analysis. By starting at 2009, the dataset captures permits issued after the 2008 Mitigation Rule, effective June 2008. The 2008 Mitigation Rule marked a shift in the USACE which may have influenced permitting decisions.

Our analysis included all types of permits the USACE issues: Regional General Permits (RGPs), Letters of Permission (LOPs), Nationwide Permits (NWPs), and Standard Individual Permits (SIPs). NWPs, and RGPs are all intended to permit projects with minimal impacts. LOPs are for projects with minor impacts, which is more than minimal but less than substantial. Any project that does not fit into one of those three permit types may qualify for a SIP, which requires a Public Notice and more involved environmental documentation. The permitting process for any of the above permit types includes an application from the applicant and a review and decision from the USACE. Applicants include anyone intending to place dredged or fill material into a wetland besides the USACE themselves. Other federal agencies with actions in wetlands are required to receive permits from the USACE. Once permit decisions are finalized and approved by the USACE, data are stored in a USACE database. The permit decision letters are also stored in the database or as hard copies.

We obtained .csv files used for detailed Freedom of Information Act (FoIA) reporting. These files contain every permit action and impact to wetlands authorized by the District. “Permit” refers to the regulatory permit given to the applicant when their work has been reviewed and authorized. For every USACE permit issued to an applicant, there is at least one permit action, such as a Nationwide Permit (NWP). There may have been multiple permit actions for a single permit, as it is possible to qualify for multiple NWPs for a single project, such as a housing development or bridge. Impacts to waters specify the impacts that were authorized for that project. The impacts in the FoIA files contain details such as acreage authorized and the duration of the impact. All acres were converted to hectares. The FoIA reports also contain information regarding compensatory mitigation required for certain impacts, although compensatory mitigation is not the focus of this study.

Detailed Permit Analysis

To further understand the specifics of what is considered a temporary impact, we investigated the permits given to the applicants. Each permit describes the impacts authorized by the permit, any special conditions set by the District and project manager, general conditions spelled out in the overall type of permit, and often includes the engineering drawings of the project or maps showing its location. Special conditions are those specifically chosen for that permit, whereas general conditions are associated with an overall permit type, such as a NWP, each time they are utilized.

One hundred sixty-five permits were selected at random, 15 from each year from 2009 to 2019, and in the approximate percentages of the number of permits for temporary impacts issued in each county (Table 2.1). Total permits issued from 2009 to 2019 per county is shown in Appendix A.

The actual permit files were all digital and pulled from the USACE databases that are used to store the permits and other application materials. All detailed permit analyses relied on the formal Department of the Army Permit. Data collected include information regarding location, impact type, applicant type, mitigation, and restoration of the temporary impact (Appendix B contains the table of information collected from each detailed permit analysis). If the permit language was vague about the type of temporary impacts, we tried to use other resources to deduce the impact type, such as engineering drawings. After the data were collected, we used Excel to query and sort the data.

RESULTS

Extent of authorized temporary impacts

From 2009 through 2019, the District authorized 12,657 permit actions for temporary impacts, with a total of 3,596 hectares of temporary impacts. By contrast, the District authorized 9,101 permit actions for permanent impacts, with 2,460 hectares of permanent impacts. A single project may have multiple actions for permanent and temporary impacts. There is no clear trend over time for either actions or hectares of temporary impacts authorized (Figure 2.2 and Figure 2.3).

Although the sum over the 2009-2019 data showed more temporary impact permit actions and hectares authorized, a few specific projects contributed greatly to the total sums. In 2013, there was a large spike in permanent impact hectares authorized and in 2016 there was a large spike in temporary impact hectares authorized. In 2013, 972 hectares of permanent impacts can be attributed to a permanent change in wetland type for a single project, restoration located near the Salton Sea. A change in wetland type is considered a permanent impact even if it is a conversion of one wetland type to another. In 2016, 1,299 hectares of temporary impacts were authorized to renew a permit for sediment removal and vegetation clearing of concrete-lined channels over a period of five years.

There is no clear trend in the type of permits (e.g. nationwide permits, standard individual permits, regional general permits) used to authorize the temporary impacts. From 2009-2019, 30 hectares of temporary impacts were authorized by Letter of Permissions, 502 hectares by Nationwide Permits, 124 hectares by Regional General Permits, and 798 hectares by Standard Individual Permits. Generally, Nationwide Permits and Standard Individual Permits account for most of the hectares of authorized temporary fill every year (Figure 2.4).

Nature of authorized temporary impacts

After collecting data from the review of 165 permits files, we categorized the temporary impacts into general categories (Figure 2.5). Note that many permits had multiple types of impacts associated with the project, thus the total is greater than 165. For example, having both construction and water diversion temporary impacts was common, and would count for both the construction and water diversion category. See Appendix C for a breakdown of the specific parings of impacts for the 165 permits. While categorizing the temporary impacts, we recorded 120 permits (73%) written with specific language detailing the temporary impact to wetlands and 45 permits that were vaguely written. As discussed in the Methods section, the vague permits were analyzed using additional information, such as engineering drawings.

The most common type of temporary impact from the 165 analyzed permits was construction related (Figure 2.5). Construction impacts included a variety of work such as creating temporary access roads, staging equipment, or temporary excavation within wetlands for the purpose of constructing something such as a pipeline, housing development, bridge, or transmission line. Other common temporary impacts included sediment removal, bank stabilization, restoration, and water diversion. Sediment removal impacts were from large equipment removing sediment and debris. Bank stabilization often included repairing eroded stream banks. Restoration temporary impacts varied but could include recontouring the stream and invasive species removal. Water diversion was often seen in conjunction with another type or impact or with a permanent impact and consisted generally of temporarily installing some type of barrier, such as straw wattles, to divert water around an area. The remaining categories had very few projects per category.

Permit conditions associated with restoring and monitoring temporary impacts

Out of the 165 permits analyzed, 11 permits had mitigation required for their temporary impacts. Three used an in-lieu fee bank, 2 used a mitigation bank, and 6 had permittee responsible mitigation to fulfill their compensatory mitigation requirements (Table 2.2). By comparison, 78 of the permits had permanent impacts as well as temporary impacts and 29 of those had compensatory mitigation requirements for the permanent impacts to wetlands.

The general condition written into the NWPs regarding temporary impacts was "temporary fills must be removed in their entirety and the affected areas returned to pre-construction elevations. The affected areas must be revegetated, as appropriate." When a special condition was in the permit, the language varied but it commonly required active restoration of pre-project alignments and conditions to the maximum extent practicable. Some special conditions included timelines for revegetation, such as requiring hydroseeding and replanting by a USACE-approved planting pallet within one month of completion of project. Some special conditions required two years of monitoring after restoring the temporary impact. Some required less specific restoration such as requiring "temporary disturbances" be returned to pre-project conditions, without mentioning contours or revegetation specifically. In total, 155 permits (94%) had requirements that addressed the restoration of temporary impacts associated with their permits, either using a general or special condition. Eighty-seven of the 155 permits had active restoration of temporary impacts within their general conditions and 68 had active restoration requirements in their specific conditions. Thirty-three (20%) of the permits had a condition requiring a monitoring report for the temporary impacts.

Most permits,78%, were for public applicants such as water districts or county flood control departments. The one permit was authorized to a nonprofit group. Regardless of the type of applicant, most had a general condition included to restore temporary impacts rather than a special condition (Figure 2.6). Within the types of applicants who had three or more permits, only transportation, local government, and the Department of Fish and Wildlife had more permits issued to them with special conditions for restoring temporary impacts rather than the general condition (Figure 2.7).

DISCUSSION

Although most research regarding Section 404 of the CWA focuses on permanent impacts and compensatory mitigation success, temporary impacts makeup a large percentage of the impacts authorized by the USACE in the arid southwestern U.S. In most years, hectares of temporary impacts exceeded hectares of permanent impacts. With so many temporary impacts authorized each year, it is notable that most of the permits we analyzed had a special or general condition regarding the restoration of temporary impacts to wetlands. However, the specific language found in the general condition associated with nationwide permits only covers a specific type of active restoration, removal of temporary fill material, and uses vague wording. Applicants proposing temporary activities such as sediment removal, a common category in our detailed permit analysis, are not required to restore their temporary impacts to pre-construction elevations unless there are special conditions written into the permit. Special conditions are an opportunity for the USACE to write a specific condition the permit applicant must adhere to. This leaves discretion up to the individual USACE District. Unfortunately, many of the special conditions are unclear regarding when post-temporary impact revegetation would be required. Some special conditions specifically require hydroseeding and replanting, but others merely say to return the wetland to "pre-project conditions". Presumably "pre-project conditions" could require replanting using a similar plant palette as to what was once there; but that is left up to the interpretation of the applicant.

The authorized temporary impacts with special conditions found within our permit analysis were clearer and more inclusive than the general conditions, mentioning "temporary impacts" rather than "temporary fill." Some special conditions require revegetation via hydroseeding, USACE approved plant pallets, and a mitigation plan for restoring the temporary impacts. Some special conditions simply require temporary impacts be restored to pre-project alignments and conditions and require a 45-day monitoring report. By restoring the hydrology within a wetland, some plants can propagate naturally and passively restore vegetation in wetlands, removing the need for active revegetation efforts (Hine et al. 2017; Nilsson et al.

2010). Yet these special conditions were not common, most conditions were general and therefore lacked specificity and instruction in how to restore temporary impacts.

Most temporary impacts from our detailed permit analysis were related to construction activities. These types of impacts, such as equipment staging and temporary access roads, disturb the hydrology and vegetation within the wetlands. If not restored, disturbances to wetland hydrology can negatively impact aquatic organisms (Coleman et al. 2011). Even temporary water diversion, a common type of temporary impact seen in our dataset and often paired with construction impacts, can harm aquatic insect communities by reducing the number of habitat types available (Walters and Post 2011). By diverting water, removing sediment, and constructing access roads, temporary impacts are temporarily altering the flow regime of the wetland, which is a primary mechanism that influences the physical habitat and therefore the aquatic biodiversity (Bunn and Arthington 2002). Restoring the temporary impacts to pre-project contours, as the many permit conditions specify, could restore the connectivity within the wetland that was interrupted. Physical habitat restoration can lead to improvements over disturbed conditions in both aquatic and terrestrial biota, even if there is no revegetation (Bond and Lake 2003; De Steven et al.2010; Pilotto et al. 2019). Revegetation does restore and improve degraded wetland and stream habitats (Gardali and Holmes 2011; Lennox et al. 2011; Mulhouse and Galatowitsch 2003). By including these general and specific conditions, and both passive and active restoration, the USACE is addressing some primary methods of wetland restoration.

However, the lack of monitoring and follow up on the restored temporary impacts may be negatively impacting the restoration efforts. USACE can conduct site visits once a project is complete, but those are done at the discretion of the District and not mandatory. Without monitoring, it is not possible to tell how (or if) the wetland is recovering from the temporary impacts. Most permits we analyzed did not have a requirement to monitor their temporary impacts post-construction and send a monitoring report to the USACE. Monitoring is important to demonstrate successful restoration and recovery of the impacted wetland, as restoration of streams and wetlands from a degraded state is not always successful (Suding 2011; Bernhardt et al. 2007). When monitoring was required in the USACE permit, it was frequently only 45 days or two years post construction. Researchers have shown a need for monitoring and management for much longer than two years to effectively evaluate restoration success (Hale et al. 2018; Lennox et al. 2011). Some researchers recommended 10 years of monitoring to ensure recovery (Kondolf and Micheli 1995). Others caution that time to wetland recovery varies, it may take decades, and that regulatory agencies should account for this in their restoration requirements (Zedler and Callaway 1999). On the ground monitoring may not be required, as it is often time consuming and expensive and remote sensing monitoring has been shown to be accurate for assessing wetlands (Shuman and Ambrose 2003). Regardless of the method, monitoring is important for evaluating the success of passive or active wetland restoration (Finlayson and Mitchell 1999; Kentula 2007). Given how many temporary impacts are issued every year in the District, the lack of monitoring may be giving us an incomplete picture of whether these impacts are really temporary.

There was no clear trend for the issuance of temporary impacts from 2009 to 2019, but Nationwide Permits and Standard Individual Permits were responsible for the most hectares nearly every year. Additionally, there was some fluctuation year to year that could be tied to overall economic health or drought years in the southwestern U.S. In 2009 there were few permanent impacts, and a lower level of temporary impacts than in 2010. This may be due to fewer development projects being constructed due to the 2008 recession, which greatly impacted housing development in California (Walker and Bardhan 2010). Additionally, 2014 and 2015 saw the lowest numbers of temporary and permanent impacts from the entire timeframe. This was in the middle of California's large 2012 – 2016 drought (Lund et al. 2018). With less rainfall and snowfall in the region, the need for some temporary impacts may have been lower. For example, in areas without urban runoff, water diversion and dewatering are less necessary when streams are dry.

Despite the lack of an overall trend, there was a large spike in hectares of temporary impacts 2016. This spike was due to a single sediment removal project in Los Angeles County. Sediment removal in Los Angeles County channels is necessary to maintain the flood management infrastructure and requires a Section 404 permit that often lasts for 5-10 years. It is significant that it accounts for so much of the impacts, as it will likely continue to account for many impacts whenever authorized and will be necessary for as long as Los Angeles County has a need to maintain its current flood management system. In general, the sediment removal category of temporary impacts is not being captured in the language of the general condition and therefore is not being restored. The problem stems from the nuanced differences between temporary impacts, temporary fill, and how sediment removal is classified as a temporary impact. Section 404 of the CWA only regulates the discharge of dredged or fill material, not the removal of sediment. However, some types of sediment removal have come to be interpreted as a temporary impact if the sediment removal methodology does not utilize clean excavation techniques. Clean excavation is not considered a regulated activity if there is only incidental fallback. For example, using a bucket excavator staged on the edge of the bank to remove sediment would be considered clean excavation, and would not require a CWA Section 404 permit. If sediment is removed with equipment in the stream that pushed or pulled sediment while removing it then the activity would be considered a temporary impact, but not temporary fill, and subject to regulations under Section 404 of the CWA. This distinction has resulted in an entire category of temporary impacts that are not being restored. Only three of the 34 sediment removal permits (9%) analyzed had compensatory mitigation requirements and only four (12%) had a special condition regarding restoring temporary impacts in their permit. Sediment removal impacts are not being restored, are rarely being mitigated, and account for a large amount of the temporary impacts authorized, as seen in 2016 with the Los Angeles County flood control maintenance permit. Flood control authorities in the U.S. spend time routinely clearing wetlands that are flood control infrastructure as to ensure the infrastructure maintains its flood control capabilities (Greco and Larsen 2014; Lassettre and Kondolf 2012; Liao 2014).

Overall, most permits in our subset were issued to public entities. This may be due to the nature of temporary impacts. Management of flood control infrastructure, likely run by a public agency, often requires a permit for sediment removal. Transportation departments, a common public agency within our dataset, are also likely to incur temporary impacts on wetlands as they are building long roads or bridges over wetlands. On the other hand, for compensatory mitigation, most applicants in California from one subset of permits were developers (Ambrose et al. 2006). This follows, as temporary impacts are not likely to require compensatory mitigation. Compensatory mitigation for temporary impacts is determined on a case-by-case basis (U.S. Army Corps of Engineers 2015). Permanent impacts have clearer requirements to offset their impacts with compensatory mitigation, including a no-net loss policy (Bendor 2009). The discretion given to the USACE to require or to not require compensatory mitigation for temporary impacts to wetlands and the results of our study suggest not many projects with temporary impacts are required to mitigate, regardless of the applicant type.

Impacts to hundreds of hectares of wetlands are authorized every year within the USACE Los Angeles District. Within our dataset, most temporary impacts were related to construction. Most permits are issued with some condition regarding restoration of temporary impacts. However, sediment removal, while considered a temporary impact to wetlands, is not considered "temporary fill," meaning an entire category of impacts, accounting for the second most common impact type in my subset of permits analyzed, are not being actively restored. Additionally, temporary impacts that are required to be restored are often not being monitored, making it challenging to determine the success of restoration of temporary impacts. Regardless of how the temporary impacts were restored, the need for monitoring within the USACE permits is clear, especially with so many hectares of temporary impacts authorized each year. It is difficult to tell whether the impacted wetlands are being restored to pre-construction conditions without at least several years of monitoring and reporting. If temporary impacts are indeed intended to be temporary, the District should ensure that measures are in place to monitor that outcome.

Tables

Table 2.1: Number of permits with temporary impacts chosen for analysis from each county in the detailed permit analysis (n=165)

County	State	Number of Permits	Percentage of total selected permits (n=165)	Percentage of all permits with temporary impacts in the District from 2009-2019
Orange	CA	28	16.97	16.15
Los Angeles	CA	27	16.36	15.49
San Diego	CA	21	12.73	13.16
San Bernardino	CA	20	12.12	12.42
Riverside	CA	14	8.49	6.69
Ventura	CA	12	7.27	5.05
Santa Barbara	CA	10	6.06	7.38
San Luis Obispo	CA	6	3.64	3.21
Maricopa	AZ	5	3.03	3.81
Mohave	AZ	3	1.82	2.47
Pima	AZ	3	1.82	2.03
Coconino	AZ	2	1.21	0.49
Gila	AZ	2	1.21	0.71
Pinal	AZ	2	1.21	0.49
Santa Cruz	AZ	2	1.21	0.49
Imperial	CA	2	1.21	0.80

Graham	AZ	1	0.61	0.22
Navajo	AZ	1	0.61	0.22
Yavapai	AZ	1	0.61	0.58
Yuma	AZ	1	0.61	0.85
Inyo	CA	1	0.61	0.71
Mono	CA	1	0.61	0.58
La Paz	AZ	0	0	1.37
Cochise	AZ	0	0	0.66
Greenlee	AZ	0	0	0.14
Kern	CA	0	0	0.16
Apache	AZ	0	0	0.52

Table 2.2: Permitted temporary impacts with and without compensatory mitigation requirements.

Mitigation Requirement for Temporary Impact	**Number of Permits**
No	154
Yes	11
In-Lieu Fee	*3*
Mitigation Bank	*2*
Permittee responsible	*6*

Figures

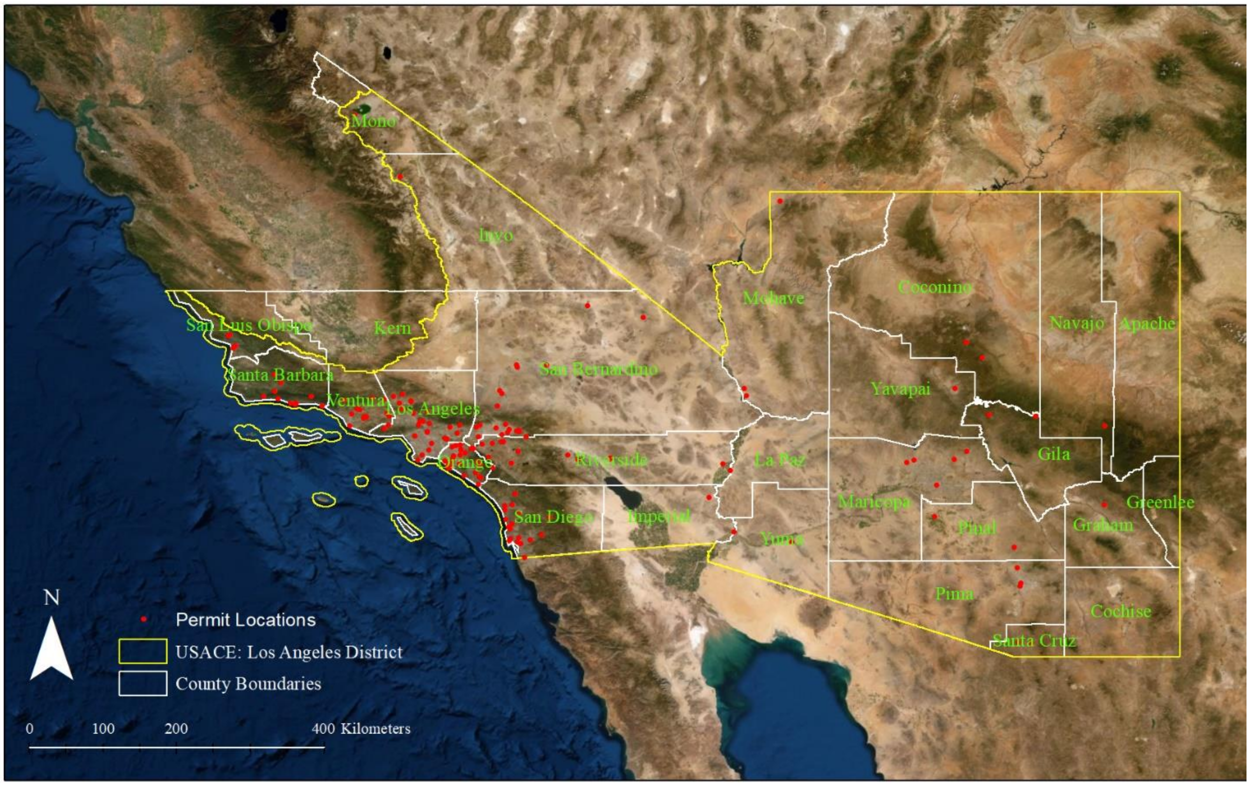


Figure 2.1: Permit locations, USACE Los Angeles District boundary, and county boundaries within study area. Imagery: Esri World Imagery WGS84

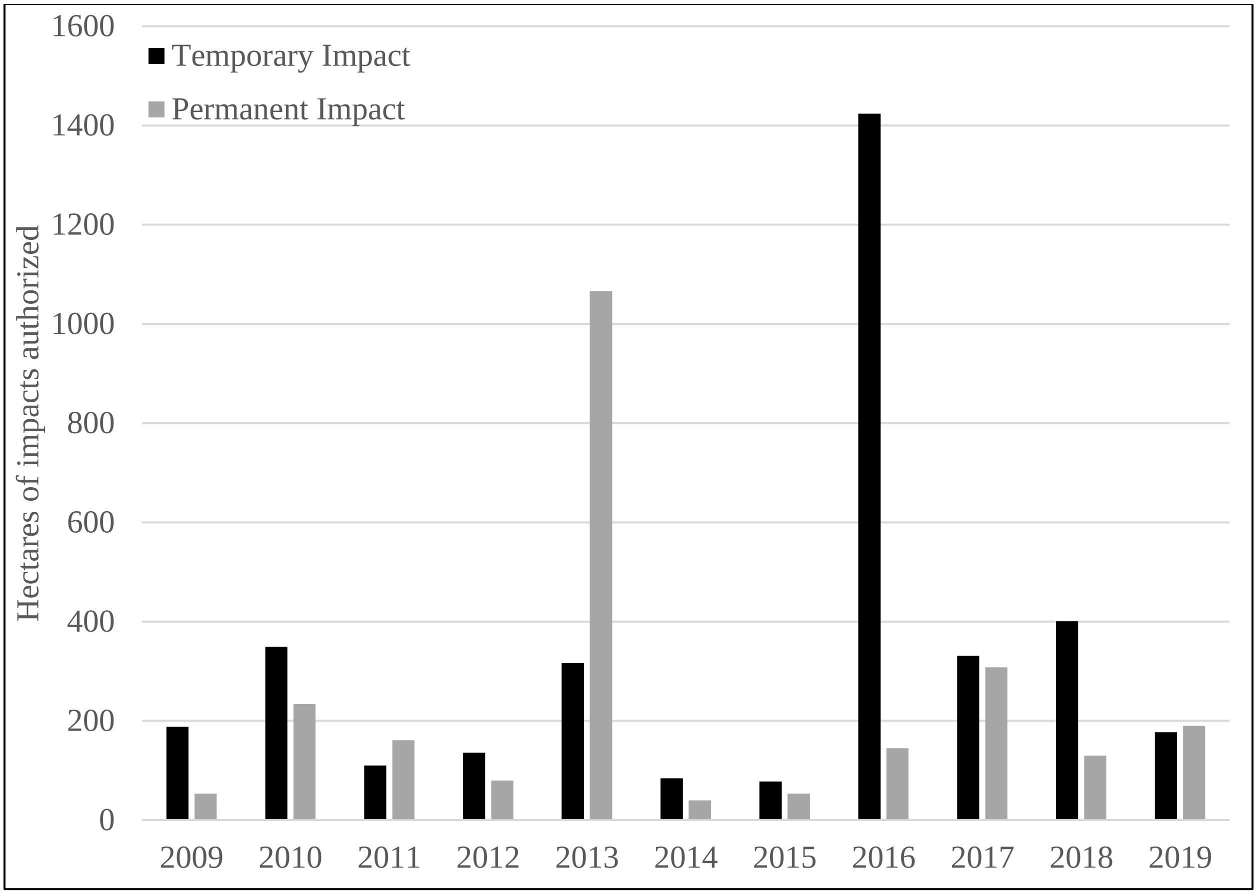


Figure 2.2: Temporary and permanent impact hectares authorized in the District from 2009 to 2019. The spike in 2016 for temporary impacts is due to a single permit authorizing thousands of acres of sediment removal for flood control. The spike in 2013 for permanent impacts is due to a single permit authorizing a change in habitat type for the purposes of restoration.

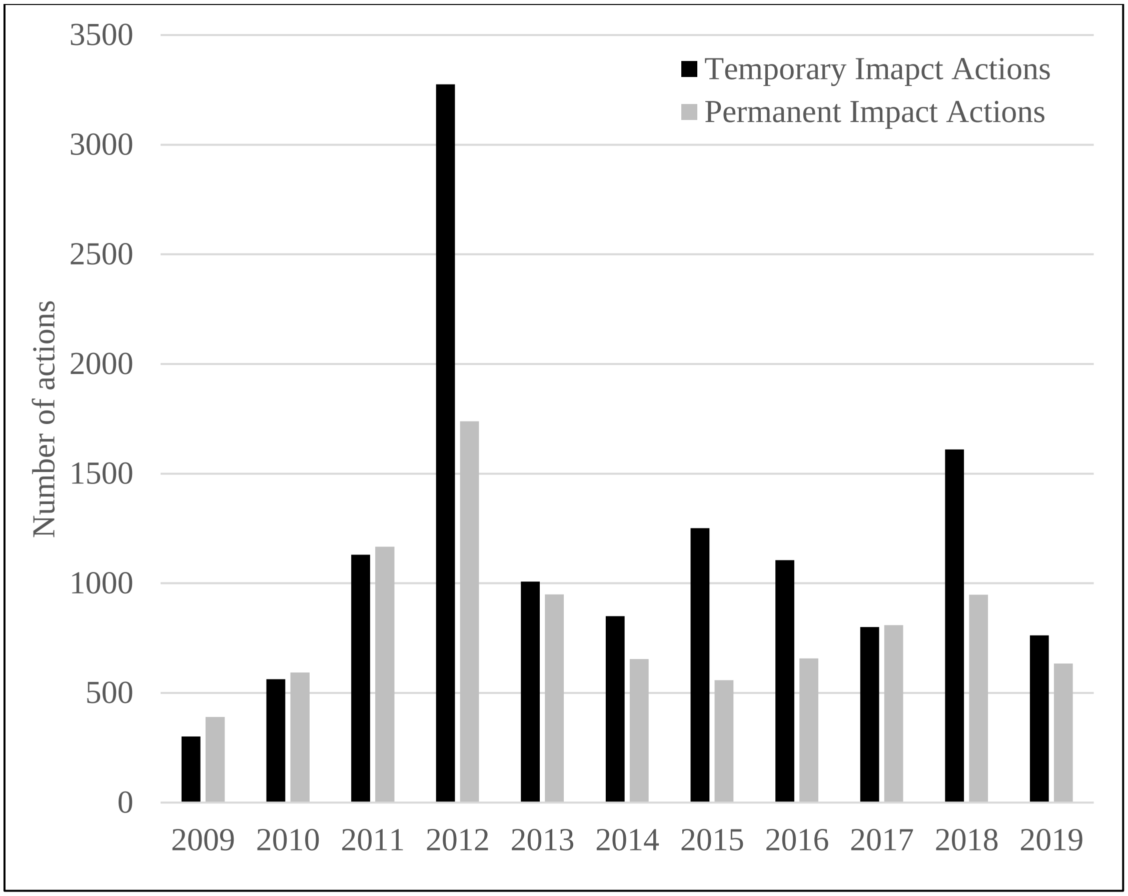


Figure 2.3:Temporary and permanent impact actions authorized in the District from 2009 to 2019. The spike in 2012 is from a long, linear project with hundreds of water crossings, each water crossing counting as an impact action.

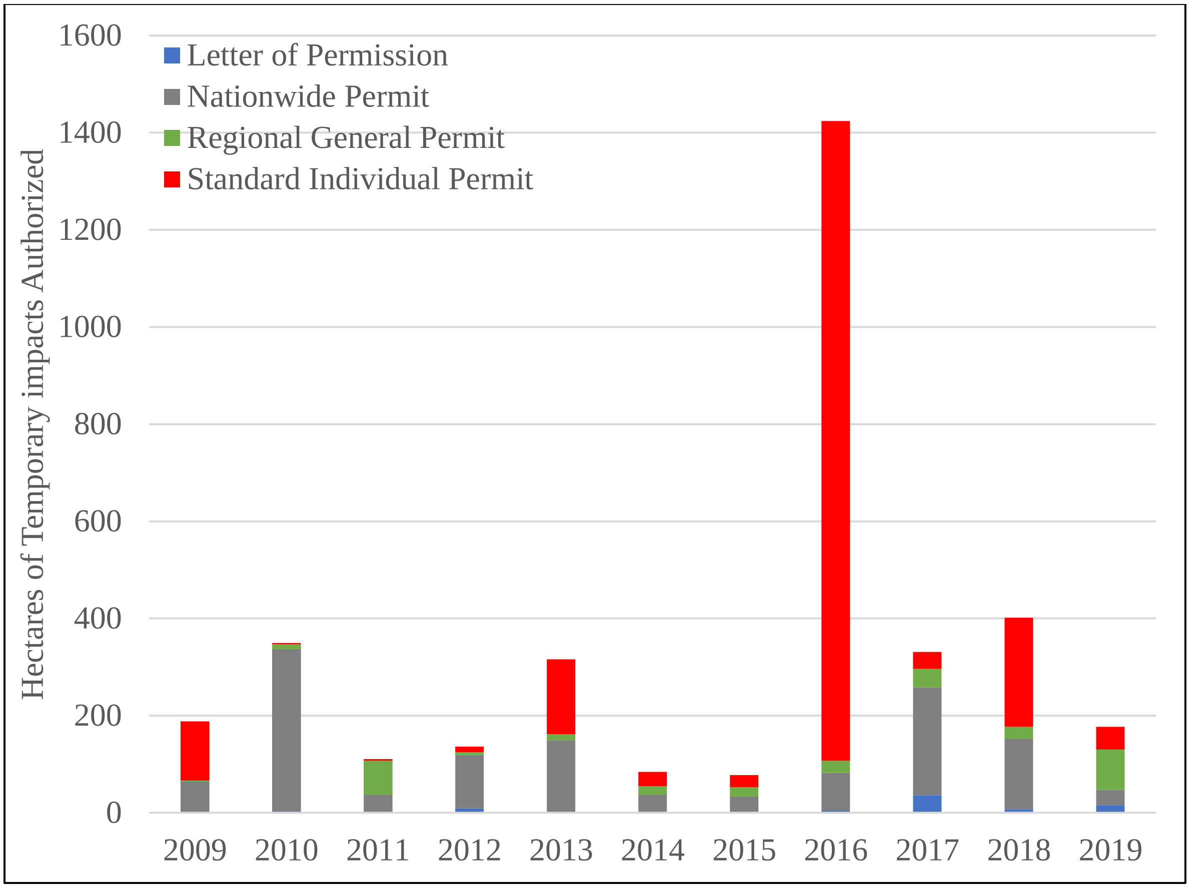


Figure 2.4: Types of permits used to authorize hectares of temporary impacts from 2009 to 2019. The spike in 2016 is due to a single permit authorizing thousands of acres of channel maintenance in Los Angeles County.

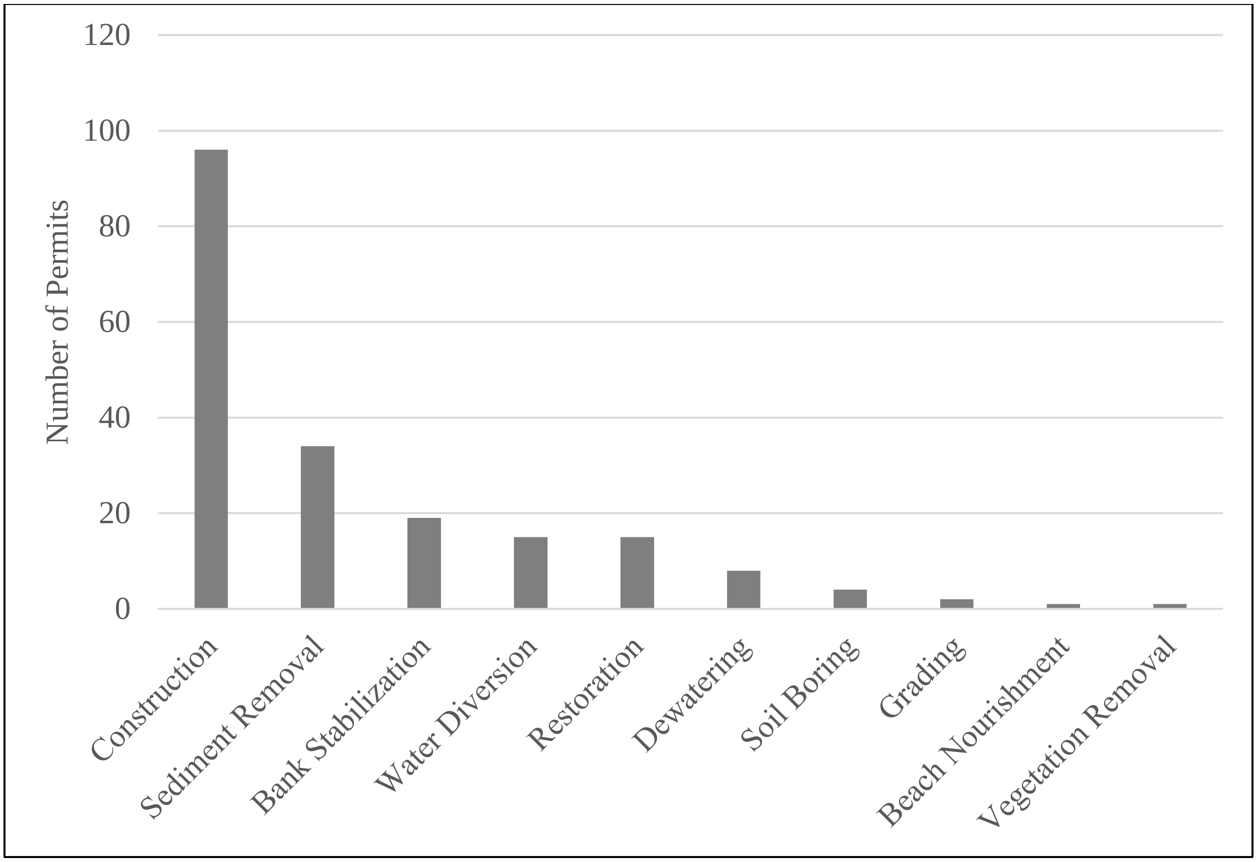


Figure 2.5: Temporary impact categories and number of permits from the detailed permit analysis dataset. Impact types counted for each permit they appear in, some permits had multiple impact times, thus total is greater than the sample size of 165 permits. Construction is clearly the most common type of temporary impact.

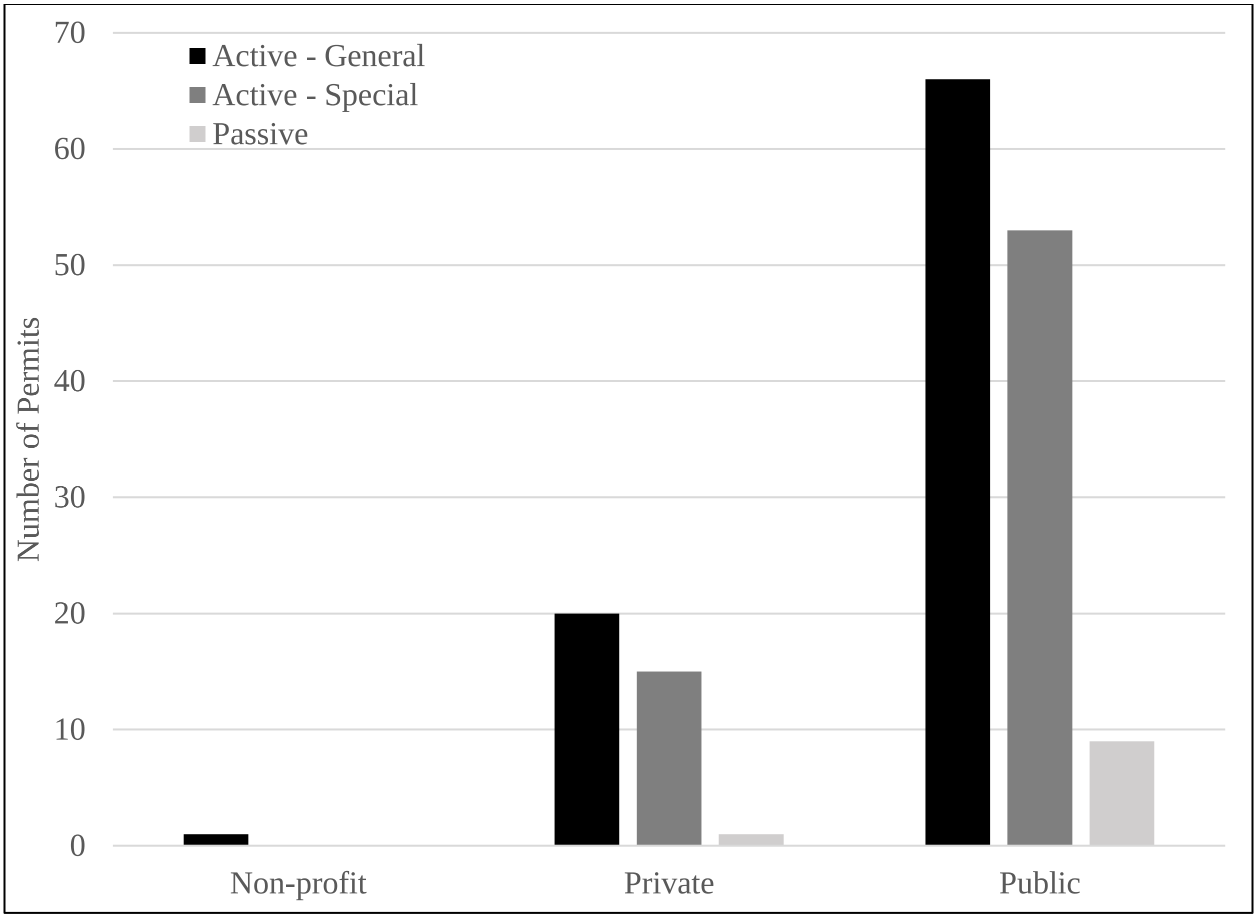


Figure 2.6: Type of restoration of temporary impacts within public, private, and non-profit permits. Public applicants received more permits in the dataset, but both were more often given general conditions to actively restore temporary impacts rather than special conditions. Passive restoration indicates no condition requiring restoration of the temporary impact.

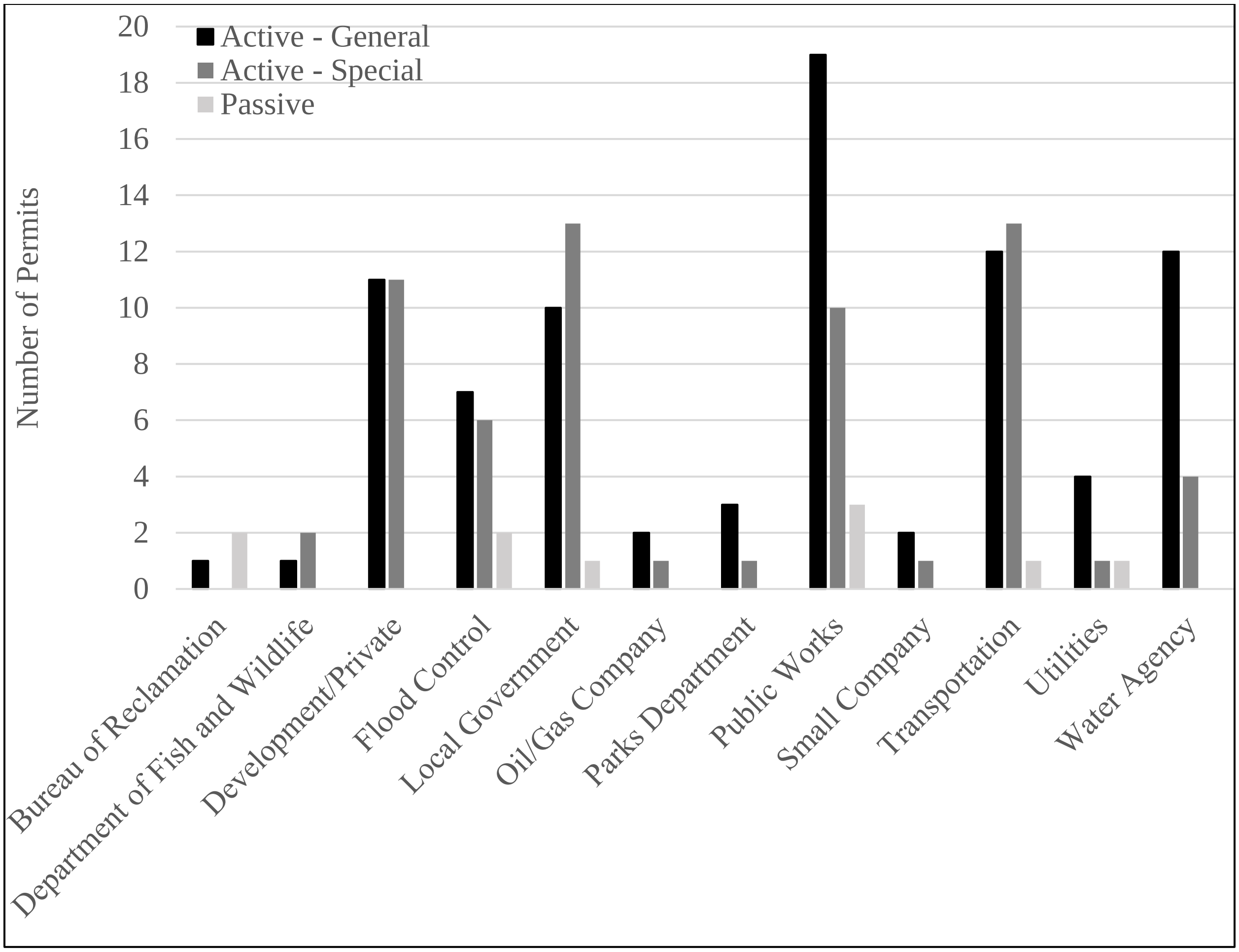


Figure 2.7: Type of restoration of temporary impacts to applicants with at least 3 permits in dataset.

Appendix 2A: Temporary impact permits issued per county

Appendix 2A: All temporary impact permits issued per county per year in the District from 2009 to 2019

	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	TOTAL	% of Total
Orange	37	44	48	27	62	58	52	70	85	46	60	603	16.15
Los Angeles	46	45	47	46	48	43	76	54	52	54	54	584	15.49
San Diego	22	34	46	48	45	27	43	57	49	54	55	490	13.16
San Bernardino	17	22	79	56	34	35	51	32	50	33	44	461	12.42
Santa Barbara	9	21	27	22	12	25	27	25	36	41	24	279	7.38
Riverside	7	16	27	23	19	14	17	24	30	33	34	255	6.69
Ventura	14	17	26	10	15	10	17	17	16	20	22	204	5.05
Maricopa	4	8	7	11	31	9	5	4	46	13	1	140	3.81
San Luis Obispo	8	4	14	10	9	11	11	14	15	10	11	124	3.21
Mohave	2	2	6	2	5	7	2	13	14	22	15	92	2.47
Pima	4	5	7	3	6	10	14	6	5	7	7	74	2.03
La Paz	0	0	5	1	4	3	1	7	10	8	11	51	1.37
Yuma	1	0	2	3	3	2	0	5	7	5	3	31	0.85
Imperial	3	3	4	7	1	2	1	4	2	1	1	29	0.80
Gila	1	4	2	1	4	1	1	3	4	3	2	27	0.71
Inyo	1	0	2	3	0	1	3	4	4	6	2	26	0.71
Cochise	1	2	0	5	1	2	9	2	0	1	1	24	0.66
Yavapai	2	0	1	3	1	4	3	0	3	3	1	23	0.58
Apache	2	0	2	2	1	2	1	2	3	2	2	22	0.52
Mono	1	0	1	0	2	4	0	5	2	4	2	21	0.58
Coconino	2	0	0	0	1	3	2	3	2	2	3	18	0.49
Pinal	0	1	3	1	4	1	2	1	2	2	1	18	0.49
Santa Cruz	0	0	0	1	4	6	1	2	2	1	1	18	0.49
Navajo	2	0	2	0	1	0	0	2	2	2	1	12	0.33
Graham	1	1	1	0	1	0	0	1	0	3	0	9	0.22
Greenlee	1	1	0	0	2	1	0	0	0	0	0	6	0.14
Kern	0	1	1	1	2	1	0	0	0	0	0	6	0.16

Appendix 2B: Information gathered from permits

Appendix 2B: Descriptions of information captured from the detailed permit analysis

Date Issued	Date permit was signed and sent to applicant
Location	City, county, state, latitude, longitude
Applicant	Type of applicant: public, private, nonprofit…
Temporary Impact Description	Detailed and generalized
Acres	Acres of authorized temporary fill into wetlands
Permit type	NWP, RGP, SIP, LOP
Permanent Impacts	Whether there were permanent impacts associated with the temporary impacts for the project
Compensatory Mitigation	Compensatory mitigation for permanent and/or temporary impacts
Mitigation Type	Mitigation Bank, In-Lieu-Fee, Permittee-Responsible
Type of Restoration of Temporary Impacts	Either specific or general conditions for active or passive restoration of temporary impacts
Land Cover	Surrounding 500m, urban, rural, agricultural, ocean, or suburban
Permit Specificity	Specific or vague regarding the temporary impacts
Monitoring Report	Monitoring reports post-construction for the temporary impacts

Appendix 2C: Types of temporary impacts in combinations from permit

Appendix 2C: Types of temporary impacts from detailed permit analysis in combinations in which they appeared in their permits (n=165)

Type of Impacts per Permit	**Number of Permits**	**Percentage (n=165)**
Construction	74	44.85
Sediment Removal	25	15.15
Restoration	12	7.27
Construction, Water Diversion	9	5.46
Bank Stabilization	6	3.64
Construction, Dewatering	6	3.64
Bank Stabilization, Construction	5	3.03
Sediment Removal, Construction	5	3.03
Soil Boring	4	2.42
Bank Stabilization, Sediment Removal	3	1.82
Bank Stabilization, Restoration	2	1.21
Grading	2	1.21
Bank Stabilization, Water Diversion	2	1.21
Bank Stabilization, Dewatering	1	0.61
Beach Nourishment	1	0.61
Construction, Restoration	1	0.61
Dewatering, Sediment Removal	1	0.61
Sediment Removal, Grading	1	0.61
Sediment Removal, Water Diversion	1	0.61
Vegetation Removal	1	0.61
Water Diversion	1	0.61
Water Diversion, Construction, Sediment Removal	1	0.61
Water Diversion, Sediment Removal	1	0.61

CHAPTER THREE: RECOVERY OF TEMPORARY IMPACTS TO WETLANDS IN THE ARID SOUTHWESTERN UNITED STATES PERMITTED UNDER SECTION 404 OF THE CLEAN WATER ACT

ABSTRACT

The United States Army Corps of Engineers, under Section 404 of the Clean Water Act, permits temporary impacts to wetlands under the assumption that they are indeed temporary. Yet recovery of wetlands from temporary impacts are not well studied or documented. Given that hundreds of temporary impacts are permitted in the arid southwestern U.S. each year, we analyzed the temporary impact recovery of wetlands in this region. We used high resolution aerial imagery to assess hydrologic and vegetation recovery of 58 projects permitted in 2011 in the arid southwestern U.S in developed lands, natural lands, working lands, and open water, assessing the specific impact site as well as the surrounding riparian area. Vegetation coverage within the impact area recovered to at least 90% of pre-impact vegetation by 2020 in over 70% of our dataset. Water Source, Average Riparian Zone Width, and Lateral Hydrologic Connectivity were not impacted by the temporary impacts for most of the sites. Evidence of Channel Alteration and Vegetation Development were impacted and fully recovered for 73% and 40% of sites, respectfully. Yet at least one site never recovered in four of the six metrics analyzed. Additionally, at least five sites only partially recovered Percent Tree and Shrub Cover, Vegetation Development, and Average Riparian Zone Width. For sites that fully recovered, time to recovery ranged from one to seven years after the temporary impact. Although most sites appear to be returning to pre-impact conditions, some sites do not recover and other sites take many years to recover, indicating that some impacts are not temporary.

INTRODUCTION

Wetlands are important ecosystems that provide habitat for wildlife, filter water, protects coastal communities, and provide recreation opportunities for humans (Barbier et al. 2011; Jackson et al. 2001; Woodward and Wui 2001). Wetland[2] protection in the United States is overseen by laws and policies at both the federal and state level. Despite laws and policies existing in the U.S. to protect wetlands for many decades, wetlands across the U.S. have been lost and are continuing to decline due to habitat destruction and other anthropogenic causes (Dahl 2011; Dudgeon et al. 2006; Lotze et al. 2006). The Clean Water Act (CWA) is the primary legislation used at the federal level to protect wetlands in the U.S. (33 U.S.C. §1251). The U.S. Army Corps of Engineers (USACE), as authorized by Section 404 of the CWA, regulates the discharge of dredged or fill material into waters of the U.S.

The USACE issues permits authorizing temporary and permanent impacts to wetlands. Permanent impacts or loss to wetlands require compensatory mitigation to offset the lost resource. The compensatory mitigation must follow specific procedures, primarily dictated by the 2008 Mitigation Rule (U.S. Army Corps of Engineers 2008). Permanent impacts and compensatory mitigation have garnered much of the attention of researchers over the years (Allen and Feddema 1996; Goldberg and Reiss 2016; Robertson and Hough 2011; Sudol and Ambrose 2002; Torok et al. 1996). The temporary impacts the USACE regulates have attracted less attention, as they are supposed to be returned to pre-project contours and conditions after the project (U.S Army Corps of Engineers 2015). But without specific studies of temporary impacts or reports produced by the USACE, the assumption that these impacts are temporary cannot be

[2] In this chapter we use "wetlands" as a shorthand for Waters of the U.S., not as the regulatory definition of wetlands.

verified. Temporary impacts may include anything that disturbs a wetland for a short amount of time, although that amount of time is not specified in the regulations. Temporary impacts in the arid southwestern U.S. are most often a result of construction, such as a temporary access road or staging area, sediment removal impacts, bank stabilization, restoration, or water diversion (Chapter 2). These impacts can affect the wetland by altering the hydrology or flow regime, removing vegetation, or removing sediment.

After an impact to a wetland, active or passive restoration may occur to the impact area to return the area back to pre-project conditions. Passive restoration, or natural restoration, refers to natural regeneration and unassisted recovery following a disturbance (Atkinson and Bonser 2020). Active restoration refers to actively restoring the hydrology and vegetation via planting after the disturbance. The USACE permits nearly always include a condition in them to actively restore, with or without planting (Chapter 2).

Actively restored wetlands generally recover two orders of magnitude faster than passively restored wetlands (Pezzati et al. 2018). Within the variation of active restoration, wetlands with just elevation and flow restoration show similar recovery whether revegetated or not (Moreno-Mateos et al. 2015). Warren et al. saw wetland recovery in salt marshes recover anywhere between 5 and 21 years depending on location, habitat type, elevation, soil salinity, and other factors (Warren et al. 2002). In southern California, compensatory mitigation restoration sites, used to offset permanent impacts, reached reference site means for hydrology and biotic structure attributes after 7-14 years post restoration, yet never recovered overall indexes and physical structure attributes (Fong et al. 2017). Additionally, other wetland types, such as prairie potholes, never recovered after restoration due to isolation, invasive species, and hydrologic regimes (Aronson and Galatowitsch 2008).

Land cover surrounding the temporary impact site may also play a role in recovery. Wetlands near agriculture or in developed areas have increased nutrient loads in their waterways due to runoff, impacting recovery efforts. Nutrient supply rates also contribute to biodiversity recovery in wetland restoration (Zedler 2000). Developed areas also have increased burdens on wetlands such as reduced biotic richness, increased hydrologic extremes, and altered morphology (Walsh et al. 2005). All these additional stressors on top of a wetland post-temporary impact may affect the recovery of the wetland in those land cover types.

The USACE permits hundreds to thousands of projects with temporary impacts to wetlands each year in the arid southwestern U.S. Yet few of them are required to monitor the recovery of the impacts to understand if it is truly temporary (Chapter 2). If temporary impacts are not actually temporary, then they should be considered permanent wetland impacts and compensated accordingly. Therefore, we investigate how sites with temporary impacts in the region are recovering to their pre-impact condition. Additionally, given the variety of land cover types and the potential for differing land cover types to impact recovery, we also examine differences in recovery based on land cover type.

METHODS

Study Area

Our study area was the entire USACE Los Angeles District, which includes all of Arizona and in California runs from the U.S. – Mexico border in San Diego up through San Luis Obispo County on the west and Mono County on the east. The District boundaries do not include the San Joaquin Valley and includes only parts of Kern, San Luis Obispo, and Mono Counties (Figure 3.1).

Data Collection

The initial dataset included all permits issued in the USACE Los Angeles District (District) in 2011. The year 2011 was selected for evaluation because it was the oldest National Land Cover Database (NLCD) available after the implementation of the 2008 Mitigation Rule. The 2011 data also allowed the most time for recovery, compared to more recent NLCD data. The dataset was obtained from the District as a .csv file used for detailed Freedom of Information Act reporting. The file for 2011 contains every permit issued in the District in that year, along with information about the project such as location, type of permit issued, and whether the authorized impact to the waterway is temporary or permanent. Types of temporary impacts were categories based on descriptions in the permit using categories developed in the previous chapter.

Projects were selected based primarily on whether we could identify the temporary impact from high resolution aerial imagery and if we could find the original permit to understand more about the temporary impact and recover. Most projects were eliminated as they were too small, less than 0.1 acre or 50 linear feet of impact to the wetland, to be resolved in the imagery. For a full explanation for why projects were excluded, see Appendix A. A total of 58 projects were selected for analysis.

For the final 58 projects, we looked in the issued permit to gather information about the nature of the temporary impact and whether active replanting occurred. We did not focus on differences between active and passive restoration since it was not possible to determine for certain using aerial imagery whether a wetland had been actively or passively restored. Although we recorded when the USACE permit required active planting, other agencies such as the California Department of Fish and Wildlife may have required active restoration requirements.

Analysis

We analyzed all sites via high resolution aerial imagery obtained from Google Earth. The years utilized for each project depended on availability and quality of the imagery. To evaluate the site prior to the temporary impact, we used the closest year before the impact that was available, which was between one and three years prior to the impact for all sites. Starting at that year we assessed each site for every possible year that good quality imagery was available. For five of the 58 sites that were in regularly maintained debris basins, we stopped analysis at the time the next sediment and vegetation removal impact occurred. For all other sites, we went until the most recent imagery as of December 2020. Since the actual impact area might only be a small portion of the whole project site, we analyzed the specific temporary impact area using percent vegetation cover. This was any type of vegetation cover, including trees, shrubs, and grasses.

We also conducted a partial aerial imagery assessment method (AIAM) for the impacts to wetlands. We used AIAM to assess landscape, hydrology, and vegetation observations as seen from remote sensing imagery (Fong 2015). It is a remote sensing method of the rapid assessment methods utilized in the field, specifically the California Rapid Assessment Method (CRAM), to quickly assess the condition of a wetland. CRAM was developed to serve as a cost-effective monitoring method for ambient wetland monitoring, restoration performance tracking, and regulatory compliance. It measures wetland ecological condition and has been extensively verified and used by regulatory and public agencies (Stein et al. 2009). AIAM was developed to mirror CRAM. AIAM has three attributes to represent ecological condition of a site: Landscape Structure, Hydrologic Structure, and Vegetation Structure. Each attribute has several metrics used to calculate the attribute score. AIAM allows us to analyze projects remotely using aerial imagery, thereby allowing us to survey the entire study area. AIAM can also be applied to historical imagery, allowing us to assess the temporary impact sites prior to the impacts. AIAM does not require imagery analysis training and eight of the 10 total metrics were adopted from CRAM existing assessment methods (McMeechan 2009; Chung 2006). The two unique metrics developed by Fong (2015) are Average Riparian Zone Width and Percent Tree and Shrub Cover.

We scored the Hydrologic Structure and Vegetation Structure attributes from AIAM. We did not score the Landscape Structure attribute since any changes in that score would not be due to the temporary impact. The Hydrologic Structure score is comprised of the sub-categories water source, average riparian zone width, evidence of channel alteration, and lateral hydrologic connectivity. The Vegetation Structure score is comprised of vegetation development and percent tree and shrub cover.

The overall assessment area for AIAM spanned the entire riparian area, including the water and riparian corridor on either side. Some sites had temporary impacts on one small area of the wetland area, and some, liked sediment removal, impacted the main channel portion. The AIAM scoring was done based on the entire riparian area, regardless of whether the impact site was in the channel or on a small side of the wetland area. For two of the 58 sites, we did not use AIAM and only analyzed percent vegetation cover due to new permanent impacts to the sides of the channel. After assessing Vegetation and Hydrologic Structure, and all sub-metrics, from AIAM, we categorized each project for each sub-metric as No Impact, Never Recovered, Slightly Recovered, and Full Recovery. Sub-metrics with No Impact were not altered by the temporary impact. Never Recovered sub-metrics declined with the temporary impact and never improved their score for the duration of the years analyzed. Metrics that made a Full Recovery regained their scores from before the temporary impact. Those that Slightly Recovered saw lower scores due to the temporary impact and improved slightly, but never to the levels they were at for that metric before the temporary impact occurred.

To categorize the land cover surrounding project sites, we used the National Land Cover Database (NLCD, https://www.mrlc.gov/data). The NLCD has 16 types of land cover at 30 by 30-meter resolution across the continental U.S. plus Alaska. We simplified these 16 land cover types into Developed Lands, Natural Lands, Open Water, and Working Lands (Appendix 3A). To calculate the NLCD land cover classification we used the ArcMap Zonal Statistics tool to calculate the majority land cover type within a 500-meter buffer around the temporary impact location. This buffer size was chosen to assess the surrounding land cover type more broadly, rather than using a buffer size as large as the pixel (30 meters). This buffer size has been used by researchers before for water quality impacts and land cover surrounding roads (Johnson and Belitz 2009; Nieszała and Klich 2021).

RESULTS

Temporary Impact Area

From the 58 projects in our dataset, the vegetation cover the year of the temporary impact was on average half of what it was before the impact occurred, with a median of only 25% of the initial cover. By year five, most of the sites had recovered to the level of vegetation coverage they had prior to the temporary impact (Figure 3.2). However, there was a lot of variability among projects. Within natural and developed land cover areas, most sites saw a sharp decline the year the temporary impact occurred; in most cases nearly all of the vegetation was removed, but in a few cases, the initial impact was less, as little as 25% reduction in cover (Figure 3.3). A few sites recovered quickly, some projects took longer, and some never fully recovered. Others recovered but saw fluctuation in the years after they recovered. Sites in developed lands recovered faster than those in natural lands. See Appendix for detailed graphs in the other land cover areas and for sites that had over 100% recovery.

In total, 24 (41%) of the sites did not reach 100% of pre-construction vegetation coverage and 14 (24%) of sites did not reached at least 90% of pre-construction vegetation coverage by the most recent available imagery for that location. The different land cover areas saw similar results; more projects reached at least 90% pre-impact vegetation coverage than those that did not.

Projects located in natural lands had twice the number of sites with less than 90% pre-impact vegetation cover, 29% in natural lands compared with 21% in developed lands (Table 3.1). Bank stabilization projects had 67% recovery to the 90% pre-impact vegetation cover level, construction had 89% and sediment removal had 77%. Sediment removal and bank stabilization, a common combination, had 75% recovery to the 90% pre-impact vegetation cover level (Table 3.2).

Overall Assessment Area – AIAM Scores

The AIAM attributes we looked at were the Vegetation Score and Hydrologic Score, which each have various sub-metrics used to calculate the overall score. The sub-metrics that make up the Hydrologic and Vegetation Scores did not always show the same patterns within the dataset. Water Source never changed, which is expected since the types of temporary impacts analyzed in this study did not change water source. Average Riparian Zone width, Lateral Hydrologic Connectivity and Percent Tree and Shrub cover all had a majority of sites that were not impacted by the temporary impact. Evidence of Channel Alteration and Vegetation Development had the most sites with fully recovered sub-category scores, 41 (73%) and 22 (40%) sites, respectively (Figure 3.4). Percent Tree and Shrub Cover had 16 (29%) sites make a full recovery after the temporary impact. Average Riparian Zone Width, Evidence of Channel Alteration, Lateral Hydrologic Connectivity, and Vegetation Development all had at least one site that never recovered at all during all years analyzed post-temporary impact. Of the sites that fully recovered, vegetation development had the most sites recovering in the first year after the impact (Figure 3.5). Evidence of Channel Alteration mainly recovered between years two and six.

The percent change of the Hydrologic Score from pre-temporary impact declined in the first few years for nearly all the sites located in natural lands. A few sites did not see any change and a few sites experienced Hydrologic Scores that were greater than before the temporary impact (Figure 3.6). All sites made some recovery if they declined during the temporary impact, time zero, and many improved in the next year or two after the temporary impact occurred. In developed lands there were a few more projects that experienced a Hydrologic Score greater than before the temporary impact, but most sites declined during the temporary impact and at least started to recover to pre-impact scores. Sites in developed lands also recovered faster than those in natural lands.

The percent change of the Vegetation Score from pre-temporary impact showed great variability, possibly due to only having two sub-metrics, Vegetation Development and Percent Tree and Shrub Cover, and thus being more prone to greater overall changes if just one of the sub-metrics changed. In natural lands, most but not all of the sites experienced a decline after the temporary impact occurred (Figure 3.7). One site had a several year temporary impact and thus experienced an increase and then a decrease in Vegetation Score in the same "year zero." Eleven sites at some point after the temporary impact occurred experienced an increase in vegetation score greater than prior to the impact. In developed lands, 10 sites saw increases after the temporary impact beyond the pre-impact vegetation score. Most sites decreased during the temporary impact and saw some improvement in the years after the impact. See Appendix 3A for open water and working lands graphs, which showed similar results but had very few projects in the dataset.

DISCUSSION

Within our study, temporary impacts were not always temporary. Vegetation cover and the AIAM Hydrology and Vegetation scores, as well as their sub-metrics, show that not every project is recovering to pre-impact conditions. Notably, Vegetation Development within the larger assessment area had 20% of sites not fully recover, and the temporary impact site specifically had 40% of sites not fully recover vegetation cover. Any project that did not make a full recovery, indicates these temporary impacts are not actually temporary, at least not within the timeframe analyzed in this dataset, since the USACE defines a temporary impact as one that is returned to pre-construction conditions (U.S. Army Corps of Engineers 2015).

For the impact site specifically, vegetation cover recovery post-temporary impact was slightly worse for sites in natural lands than in developed lands, working lands, or open water. This may be due to differences in water regimes within these systems. In the arid southwest, the climate is dry and prone to droughts. But in developed areas, increased impervious surface and runoff can increase flows in waterways (Sterling et al. 2013; Walsh et al. 2012). It is possible temporary impact recovery is assisted in developed land cover areas due to increased water availability. More detailed analysis of the types of vegetation regrowth and recovery between natural and developed lands may shed light on differences in overall recovery post-temporary impacts. Differing flood regimes in developed lands may select for different plants with varying tolerances for flooding (Colmer and Voesenek 2009). Climate models indicate the arid southwest will only become more arid and experience more droughts under current climate change scenarios (MacDonald 2010). The differences in post-temporary impact vegetation recovery seen in this dataset may be exacerbated in this region in the future, as natural lands with less water availability will have an even harder time recovering vegetation.

The Hydrologic and Vegetation Scores from the AIAM riparian area assessment shows that not all metrics are affected by temporary impacts. Water Source, Average Riparian Zone Width, Lateral Hydrologic Connectivity and Percent Tree and Shrub Cover were the sub-metrics that had at least 50% of sites with no impact post-temporary impact across all years of analysis. Types of temporary impacts in our dataset would not be expected to affect Water Source or the Lateral Hydrologic Connectivity of a wetland. Average Riparian Zone Width and Percent Tree and Shrub Cover also had many projects that were not affected by the temporary impact, likely due to the size of the full AIAM assessment area compared with the temporary impact area specifically. The AIAM assessment area considers both sides of the riparian zone, and the temporary impact may have only occurred on one side, or just a small portion of the overall area. The Percent Tree and Shrub Cover had no sites that never recovered at all. This is likely due to how that sub-metric is calculated, as it considers the riparian area and channel area as well as the total tree and shrub cover in the full assessment area. If a temporary impact such as sediment removal in the main channel expanded the channel area, the percent tree and shrub cover would seem larger too, as by comparison it would be covering a larger percentage of possible riparian area. This may also explain the increased volatility in recovery seen in our analysis, changing channel sizes and riparian area sizes may have had an outsized influence on this metric.

Evidence of Channel Alteration and Vegetation Development experienced the most fully recovered sites of all the AIAM sub-metrics. This points to both the influence temporary impacts have on this sub-metric, and their ability to recover. However, both these categories also saw several projects that only partially recovered and a few that never recovered. Evidence of Channel Alteration and Vegetation Development were heavily impacted by temporary impacts, as those sub-metrics considered visible alteration of the channel and the condition of the vegetation, both likely to be impacted by a temporary impact such as temporary staging areas, bank stabilization efforts, or sediment removal. Vegetation development takes time, and other wetland recovery analyses have shown that even a century after a restoration of a wetland, plant assemblages were a quarter lower than reference sites (Moreno-Mateos et al. 2012).

Recovery times of temporary impacts differed within our dataset based on the metric and land cover type, but on average vegetation coverage within the impact site returned to pre-impact coverage levels around year five and other metrics within the full assessment area returned by year seven. This is slightly faster than compensatory mitigation recovery timeframes in the southern California region (Fong et al. 2017). But these recovery times are within the range seen in other wetland restorations (Warren et al. 2002; Craft et al. 2003). However, this does not address other restoration recovery indicators such as soil properties. In coastal mangrove wetlands, some properties recovered between 18-28 years, but some nutrients never recovered (Osland et al. 2012). AIAM also does not address more nuanced aspects of wetland restoration that would be assessed from the field using a rapid assessment method, such as recovery of topographic complexity (Sutula et al. 2006). Despite these limitations, remote sensing and using the AIAM metrics and target vegetation coverage of the impact area allowed us to collect a wide range of data over many years for projects across our study area.

Utilizing aerial imagery and analyses such as AIAM would be beneficial for the USACE to continue monitoring temporary impact recovery to ensure impacts adequately recover. Using aerial imagery would allow the USACE to quickly assess a wide range of project locations that may otherwise be time consuming to travel to for a field visit (Morgan et al. 2010). However, it would be limited to sites with large enough impacts to be seen in the available aerial imagery. Still, either aerial imagery analysis or field visits could be used to monitor for temporary impact sites that do not recover. Additionally, monitoring should be required four or five years after the temporary impact to see if vegetation has returned to pre-impact condition, and longer for sites that do not appear to be recovering.

The sites that did not fully recover should be considered as permanent impacts, and appropriately compensated. Even sites that only partially recovered would not be considered temporary impacts since, according to the USACE definition, temporary impacts are those that, after the project has finished, are returned to pre-project conditions (U.S. Army Corps of Engineers 2015). Additionally, sites that took a long time to recovery should not be considered temporary. When calculating compensatory mitigation, the USACE considers temporal delays between the project impact site and the mitigation site, and unexpected delays would be handled as a compliance action with the permit and permittee. For restoration of temporary impacts, the USACE guidance does recommend, on a case-by-case basis, compensatory mitigation to offset temporal loss in functions but does not specify a length of time that would trigger such a scenario.

The USACE should develop a uniform procedure and policy for handling permits with temporary impacts to wetlands that do not make a full recovery. Although there is some USACE guidance, it is case-by-case and given the number of sites not fully recovering, the procedure to handle non-temporary temporary impacts should be more stringent. One way may be to view them as permanent if they do not recover after a certain amount of time and require a set amount of compensatory mitigation. This could be written into the permits as a condition upfront, thereby incentivizing applicants to ensure their temporary impacts make full recoveries.

While most sites with temporary impacts recovered, many of them did not, and given the hundreds and thousands of temporary impacts to wetlands authorized by the USACE in the arid southwestern U.S. each year, those impacts are further harming an already vulnerable ecosystem. Temporary impacts are not well studied across the U.S. and if they are as abundant as they are in this study area, it would be worth further investigation to determine if temporary impacts are fully recovering in other areas of the U.S.

Tables

Table 3.1: Number of temporary impact sites and whether they recovered to at least 90% pre-impact vegetation cover based on land cover type.

	Developed Lands	Natural Lands	Open Water	Working Lands	Total
Less than 90% pre-impact vegetation cover	4 (17%)	8 (29%)	1	1	14
At least 90% pre-impact vegetation cover	19 (83%)	20 (71%)		5	44

Table 3.2: Number of temporary impact sites by temporary impact type and whether they recovered to at least 90% pre-impact vegetation cover.

Type of Temporary Impact	No	Yes	Percent Recovered at least 90%
Bank Stabilization	2	4	0.67
Bank Stabilization, Construction	1		0
Construction	1	8	0.89
Construction, Boring	1		0
Construction, Sediment Removal, Bank Stabilization		1	1
Dewatering, Construction		1	1
Grading		1	1
Restoration		1	1
Sediment Removal	5	17	0.77
Sediment Removal, Bank Stabilization	2	6	0.75
Structure Removal		1	1
Vegetation Removal		1	1
Water Diversion		1	1
Water Diversion, Construction	1	1	0.5
Water Diversion, Sediment Removal		1	1
Water Diversion, Sediment Removal, Bank Stabilization	1		0

Figures

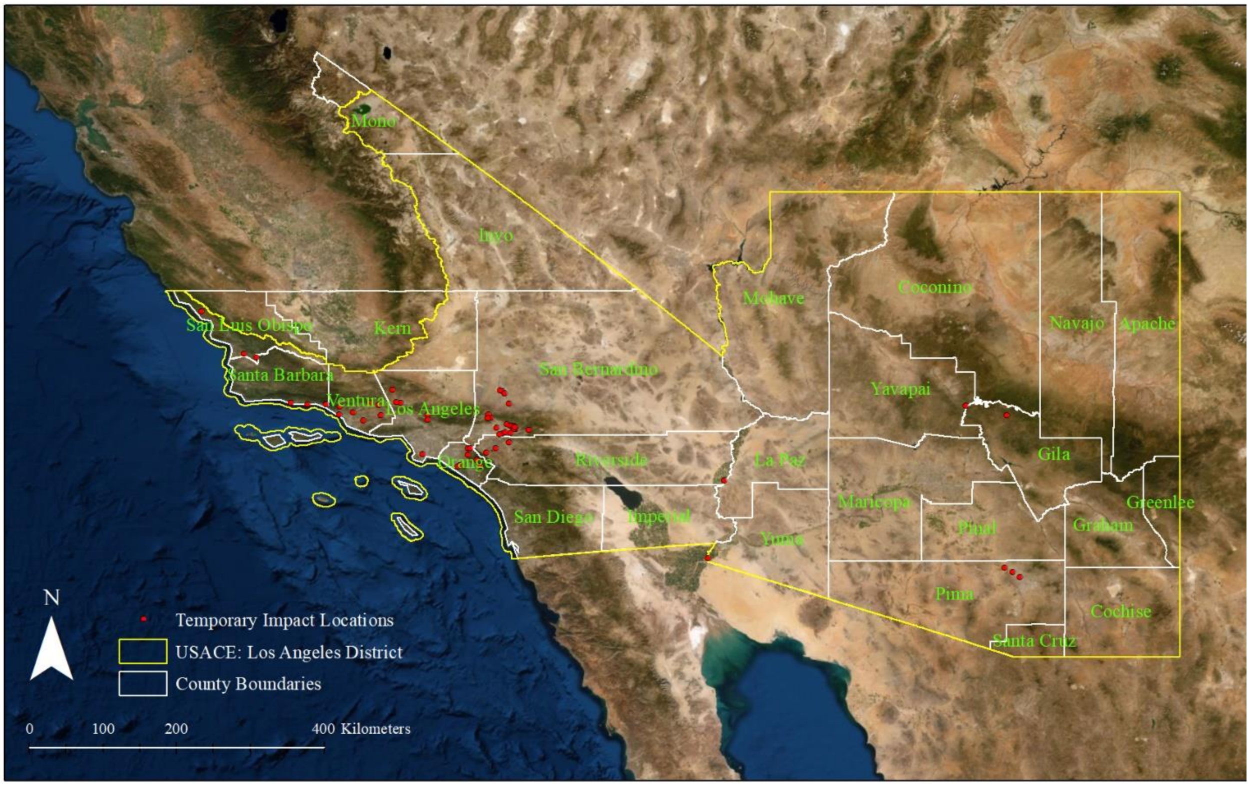


Figure 3.1: Location of temporary impacts used in dataset, District boundary, and county boundaries. Imagery: Esri World Imagery WGS84

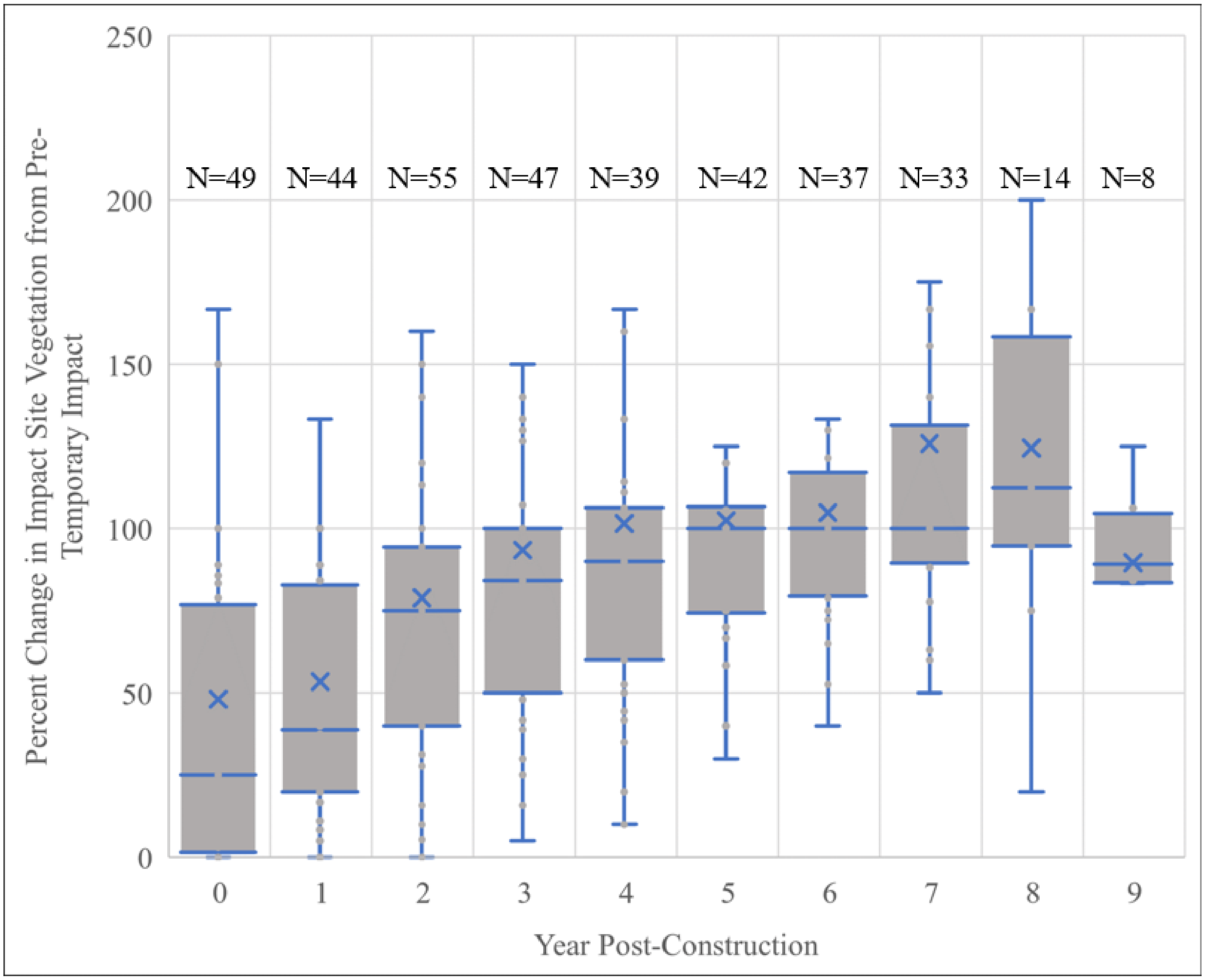
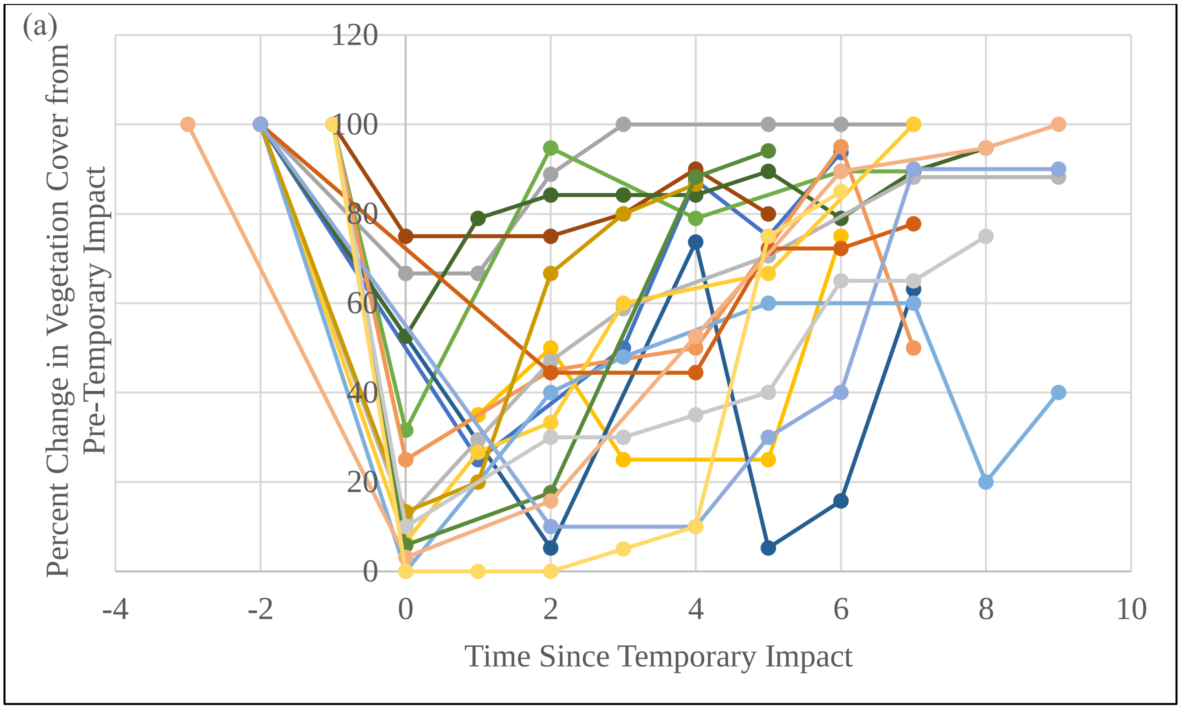


Figure 3.2: Percent change to impact site vegetation since pre-temporary impact. X is mean, dashed line is median, and outliers have been removed.



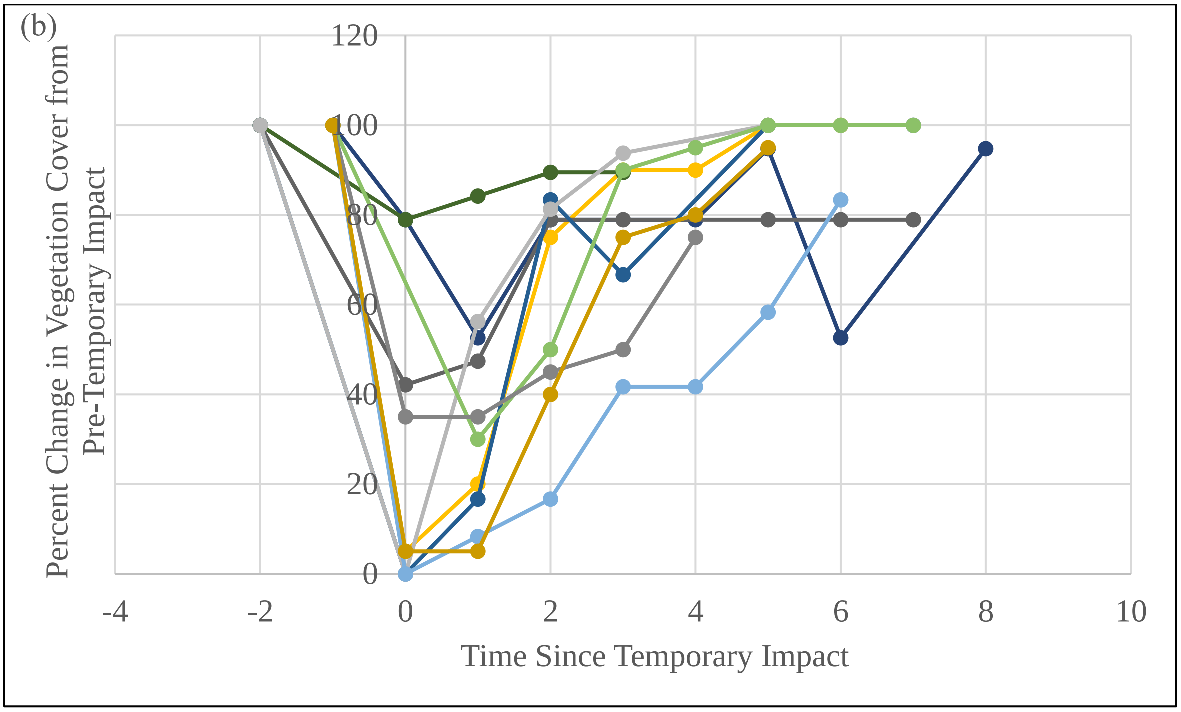


Figure 3.3: Percent change in vegetation coverage at temporary impact site from pre-temporary impact in (a) natural land cover locations and (b) developed land cover locations. Locations that had over 100% change, therefore more vegetation than pre-impact, are removed from this graph.

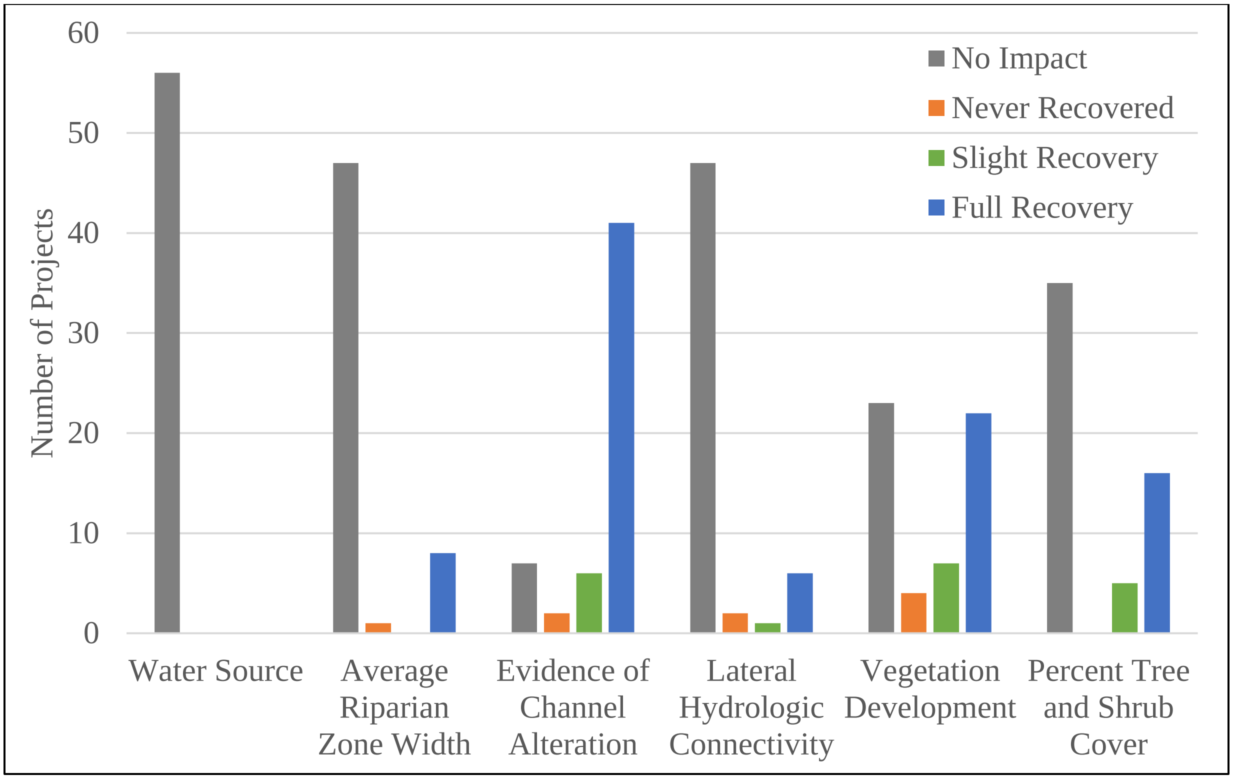


Figure 3. 4: AIAM sub-category results for all land cover types and full assessment areas, n=56.

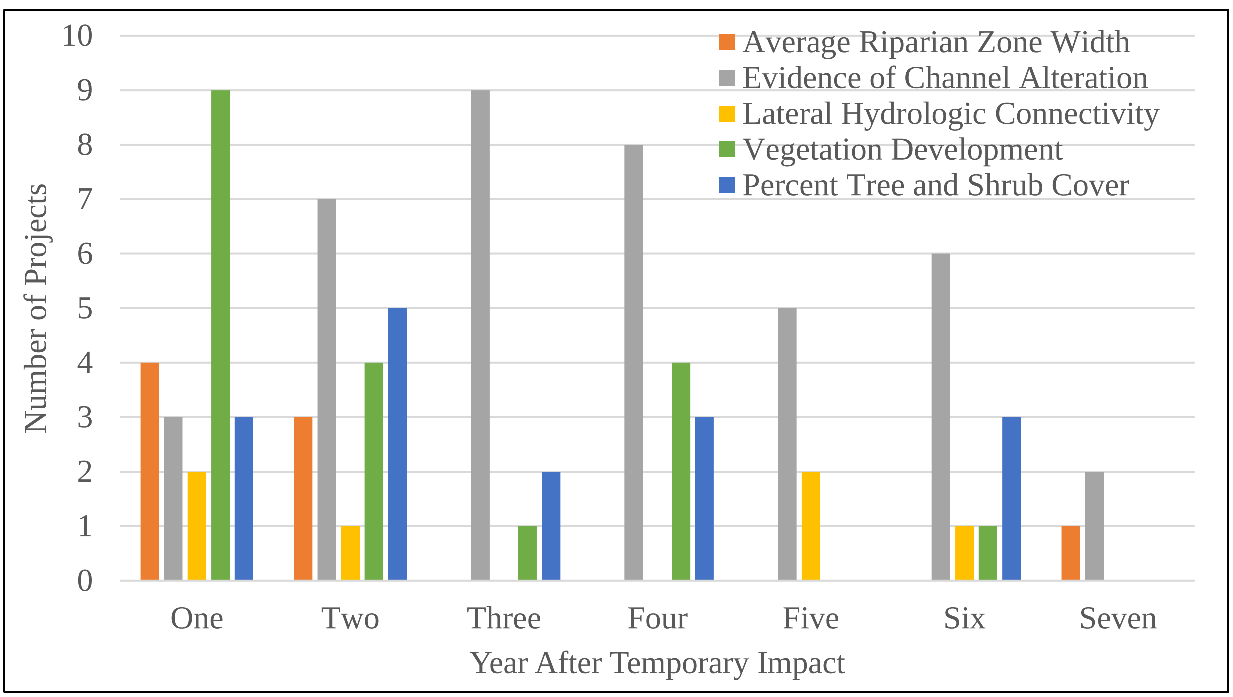


Figure 3.5: AIAM sub-categories for assessment areas which made a full recovery by year full recovery was reached, "Water Source" is not included as it was not impacted for any project.

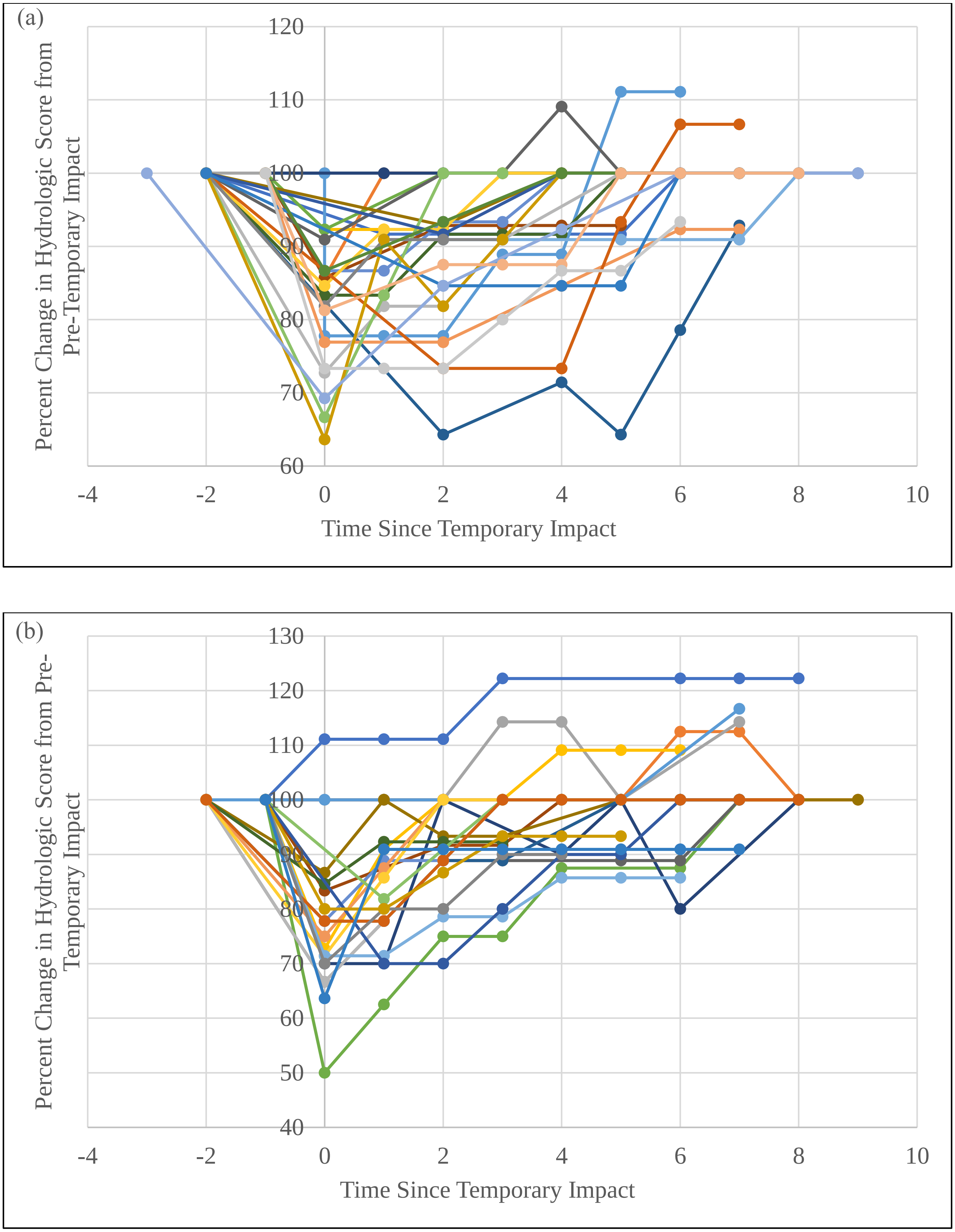


Figure 3.6: Percent change in hydrologic score from pre-temporary impact for full AIAM assessment areas in (a) natural lands and (b) developed lands.

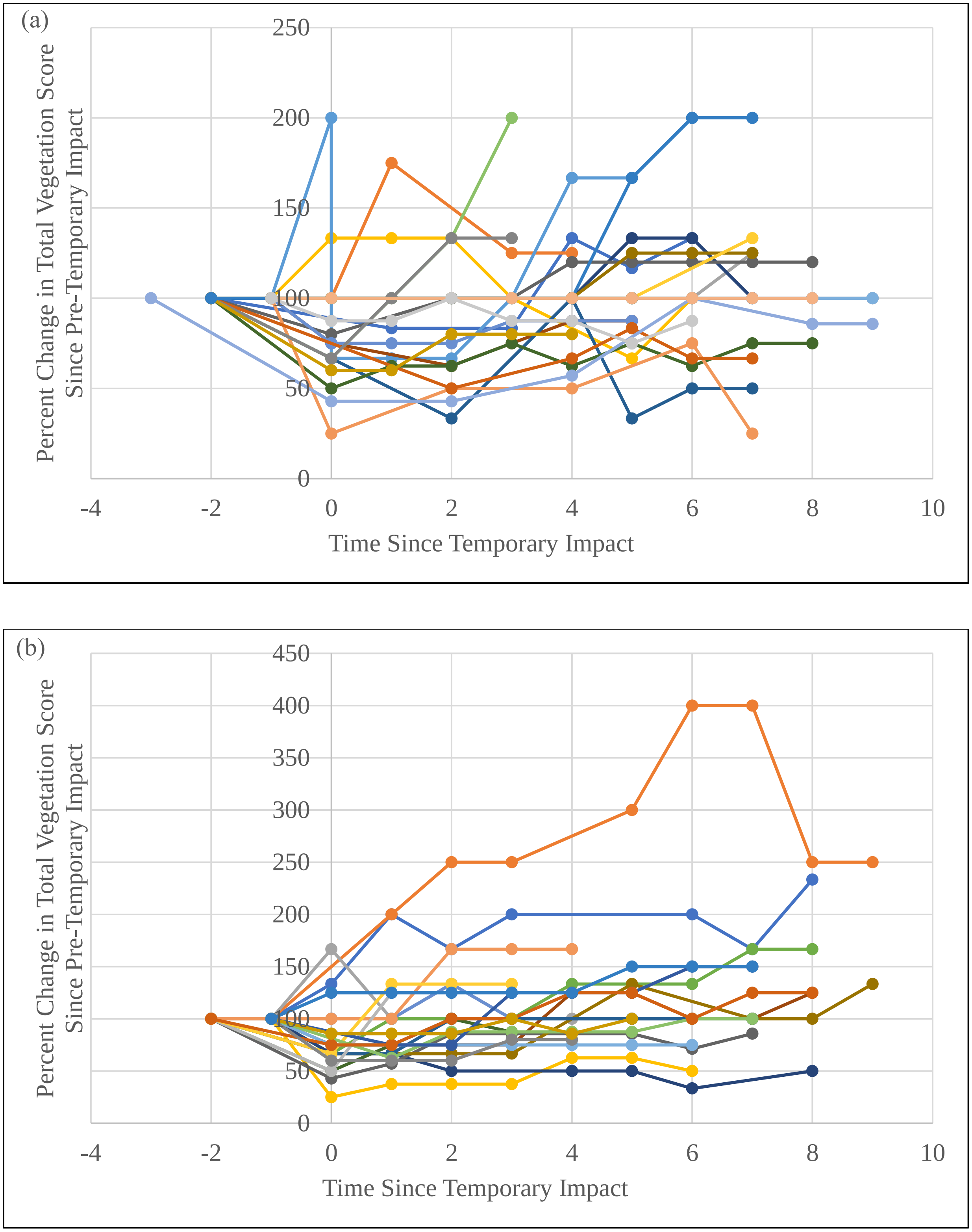


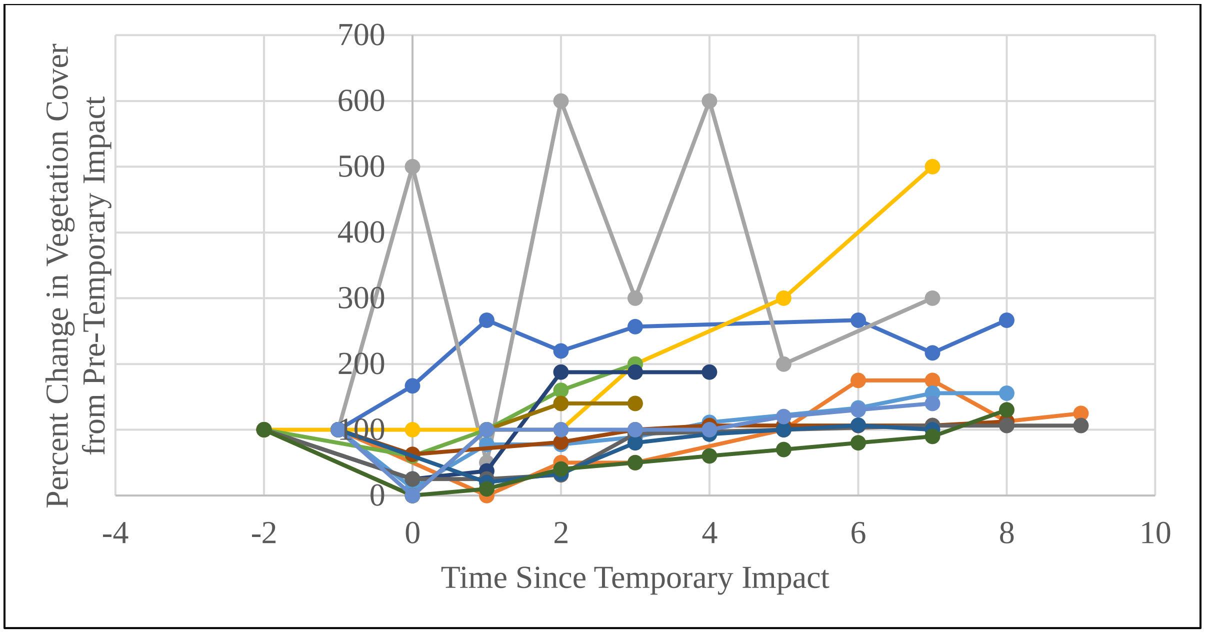
Figure 3.7: Percent change in total vegetation score since pre-temporary impact for full AIAM assessment areas in (a) natural lands and (b) developed lands.

Appendix 3A: Reasons for exclusion and additional land cover analyses

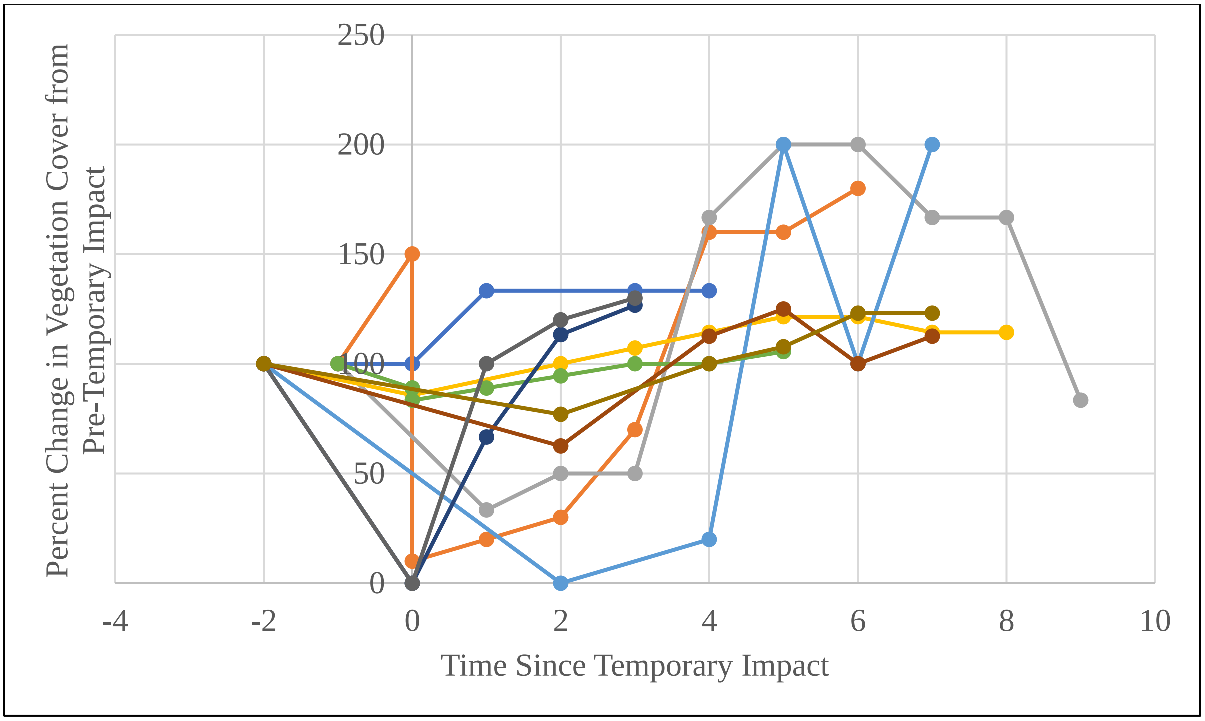
Appendix 3A.1: Reasons why a permit was not included in the dataset.

Reason for Exclusion	Number of Permits
Too small	736
Poor Google Earth Imagery - Transmission Project	68
Unable to see TI	56
Ocean	36
Section 10	29
Regularly maintained, unable to distinguish TI	29
Sparse Vegetation - Desert Transmission Line	18
Earthen Channel, No Vegetation	16
All Concrete	11
Unable to find permit	11
Duplicate	10
Poor Google Earth Imagery	9
Project built, no impact to water seen	7
Permanent impact obscuring TI	7
Dam	6
Historical - Missing data	4
Sparse vegetation - Desert River	4
Unable to see TI, under bridge	4
Beach	2
Lake, work underwater	2
Wetland enhancement project	2
Tidal Lagoon	1
Project not constructed	1
Roadside ditch	1
Project ongoing	1

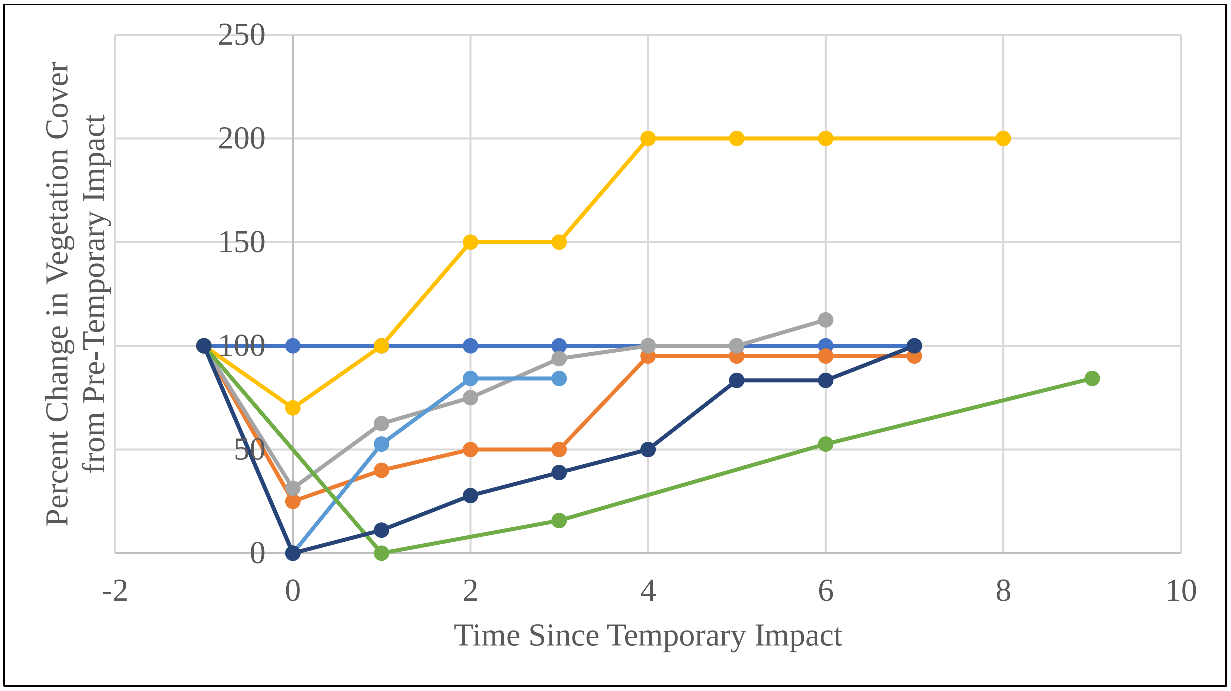
Appendix 3B: Percent change in vegetation cover, hydrologic score, and total vegetation



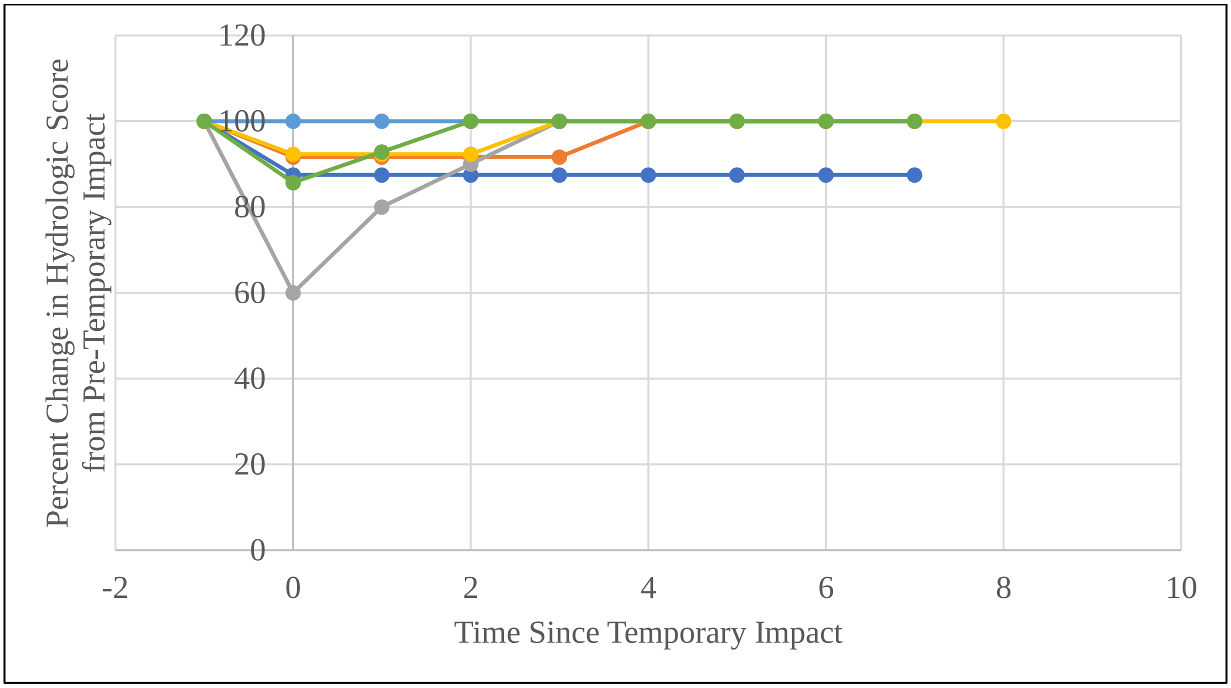
Appendix 3B.2: Percent change in vegetation cover from pre-temporary impact for projects that went over 100% in developed lands.



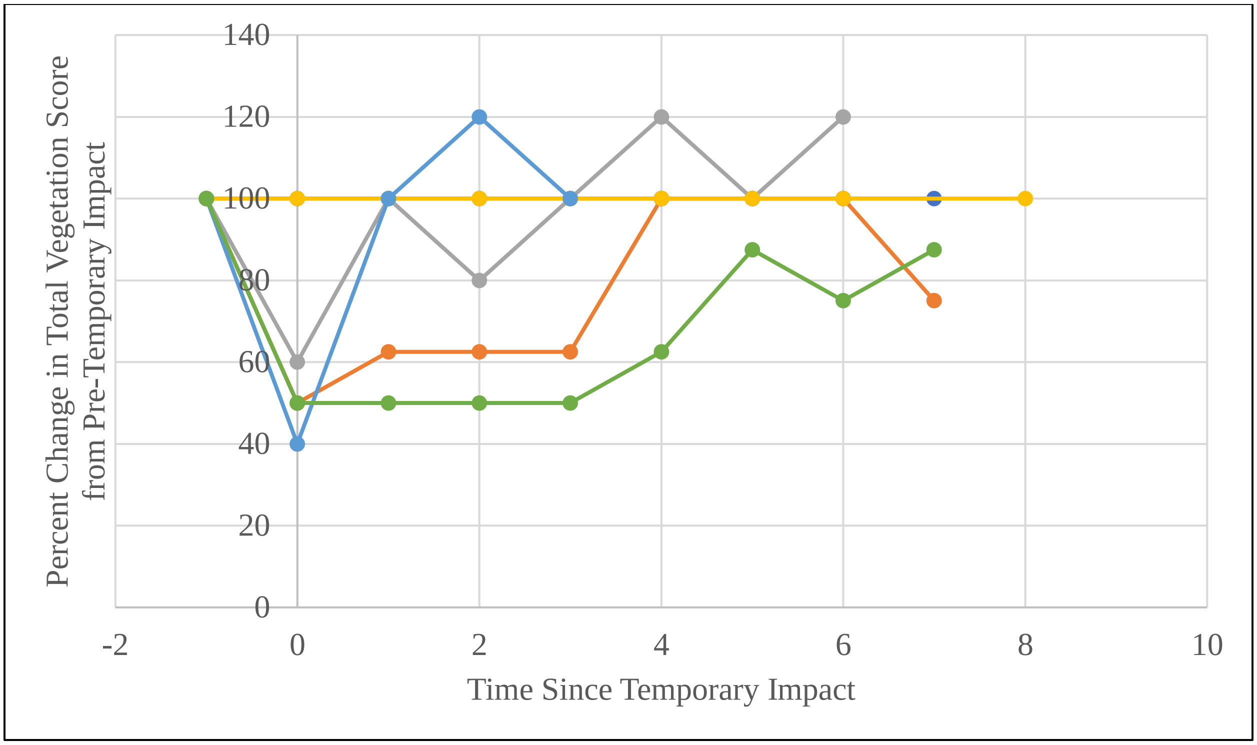
Appendix 3B.3: Percent change in vegetation cover from pre-temporary impact for projects that went over 100% in natural lands.



Appendix 3B.4: Percent change in vegetation cover from pre-temporary impact for projects located in working lands and open water.



Appendix 3B.5: Percent change in hydrologic score from pre-temporary impact in working lands and open water for full AIAM assessment area.



Appendix 3B.6: Percent change in total vegetation score from pre-temporary impact in working lands and open water for full AIAM assessment area.

CHAPTER FOUR: LAND COVER SURROUNDING TEMPORARY IMPACTS TO WETLANDS IN THE ARID SOUTHWESTERN UNITED STATES PERMITTED UNDER SECTION 404 OF THE CLEAN WATER ACT

ABSTRACT

Wetlands in the United States are under threat from a myriad of sources including habitat destruction. Despite their known importance and their historically low levels, activities that degrade wetlands continue, including impacts permitted under the Clean Water Act. While permanent impacts and mitigation for wetlands have been well studied, temporary impacts to wetlands are less understood. Hundreds of temporary impacts to wetlands are permitted each year in the southwestern U.S., but little is known about the location of these impacts. Given increases in human population and development pressures in the arid southwestern U.S., knowing where impacts are occurring may help focus resources to better protect wetlands. We analyzed impacts permitted under Section 404 of the Clean Water Act by the United States Army Corps of Engineers (USACE) in the southwestern U.S. in 2011, 2013, and 2016 and a subset of permits in greater detail from 2009 – 2019. The results showed that temporary impacts due to construction, sediment removal and restoration were more common in natural lands while dewatering and water diversion were more common in developed lands. Most temporary and permanent impacts throughout the entire study area in 2011, 2013, and 2016 occur in natural lands and were individually less than 0.1 acre (0.04 hectare). Additionally, long, linear projects appear to account for many of the impacts in natural lands; however, they are small in total impact acreage. The location and number of impacts in natural lands indicate impacts to wetlands not currently developed.

INTRODUCTION

The area of wetlands in the U.S. has been reduced by roughly 50% over the past 200 years (Dahl 1990). Their loss and continued threat can be primarily attributed to human activities such as habitat destruction (Lotze et al. 2006; Dudgeon et al. 2006). The primary regulatory tool for protecting the remaining wetlands is the U.S. is the Clean Water Act (CWA). Section 404 of the CWA regulates the discharge of dredged or fill material into waters of the U.S. and is overseen by the U.S Army Corps of Engineers (USACE) (33 U.S.C. §1251).

The USACE oversees Section 404 of the CWA by issuing permits authorizing impacts to wetlands[3]. Most research on Section 404 of the CWA has been focused on wetland loss as permitted by the USACE (Goldberg and Reiss 2016; Kelly 2001; Kentula et al. 1992; Sifneos et al. 1992; Torok et al. 1996). To offset the permanent impacts and loss to wetlands, compensatory mitigation is required. Mitigation requirements have existed since the 1970's but have changed over the years based on new rules and regulations (Hough and Robertson 2009). Most recently, the USACE and the U.S. Environmental Protection Agency published the 2008 Mitigation Rule (2008). In addition to the research focusing on wetland loss, researchers have also focused on the effectiveness of compensatory mitigation (Robertson and Hough 2011; Duncan et al. 2018; Goldberg and Reiss 2016; Robertson et al. 2018; BenDor and Riggsbee 2011).

Section 404 of the CWA also authorizes USACE to permit temporary impacts to wetlands. Temporary impacts are defined as minor impacts to wetlands occurring for a short time due to authorized activities. After the impact occurs and the authorized activity is completed, depending on the conditions in the permit, the impact is either actively or passively restored to

[3] In this chapter we use "wetlands" as a shorthand for Waters of the U.S., not as the regulatory definition of wetlands.

pre-project conditions by the applicant (U.S. Army Corps of Engineers 2015). Temporary impacts are a major category of impacts to wetlands, but they have not been studied extensively.

Given the increasing human population, resulting expanding development, and the unique but dwindling wetlands in the southwestern U.S., knowing where temporary impacts to wetlands are occurring can shed light on why they are occurring and how to better focus resources to protect wetlands in this region. If most impacts are occurring in undisturbed land, rather than developed land that may indicate increased impacts to otherwise undisturbed wetlands. Conversely, if most impacts are occurring in developed lands, these may be the result of temporary impacts related to flood control systems and construction types commonly seen in developed areas. Additionally, land cover types are changing over time in the U.S (Homer et al. 2020). Temporary impacts to wetlands may be changing over time as well due to differences in land use or development patterns in the region.

The southwestern U.S. covers a wide variety of wetland resources, ranging from the famously channelized Los Angeles River to vulnerable desert ephemeral washes. Within California, greater than 91% of historical wetlands have been lost in the past 150 years (Dahl 2011). Desert wetlands in the southwestern U.S. are a particularly vulnerable aquatic environment (Minckley et al. 2013). Wetlands in this region are also under pressure from climate change, groundwater extraction, and invasive species (Haig et al. 2019; Davis et al. 2017). With multiple stressors to wetlands, temporary impacts to wetlands are important to understand within this region as another potential stressor.

The southwestern U.S. covers a highly populated geographic area, adding to the pressures on wetlands in the region. Beginning in and throughout the 20th century, California experienced rapid population growth (Johnson et al. 2020). Since 2010 alone, California's population has grown by 2.7 million or 6.1% (Finance 2019). In Arizona, rapid population growth began in the late 20th century (Rex 2000). Since 2010, its population has grown by 1 million, nearly 14% (U.S. Census 2019). This rapid population growth has led to development and change in land cover in the southwestern U.S. In California, developed lands increased by 37% in the last quarter of the 20th century (Sleeter et al. 2011). In the central Arizona region in the late 20th century, urban land cover quickly displaced native desert and agriculture lands (Jenerette and Wu 2001).

To better understand where temporary impacts are authorized in the arid southwest, and the nature of these impacts, we address the following questions:

1. What types of temporary impacts have been permitted and do they vary with different types of land cover?
2. How have impacts to wetlands, temporary and permanent, changed over time in relation to the land cover where they are being permitted?

In addition to those two questions, as we began the initial data analysis it became clear that several long, linear projects, seemed to have a disproportionate influence on the results. A single project, such as constructing a new power transmission line across the state, could cross hundreds of wetlands. Therefore, we asked a follow up question:

3. What proportion of the overall permitted impacts, temporary and permanent, to wetlands in different land cover types have been caused by linear projects?

METHODS

Study Area

The USACE Los Angeles District (District) includes Arizona and southern California, running from the U.S – Mexico border in San Diego up to San Luis Obispo and Mono Counties (Figure 4.1). The District boundaries do not include the San Joaquin Valley and include only parts of Kern, San Luis Obispo, and Mono counties.

USACE data selection

Our dataset consists of all permits issued in the District from 2011, 2013, and 2016. The years were selected due to availability of land cover data in the region (see below). A subset of permits for detailed analysis were selected from all permits issued from 2009 and 2019. They were selected to reflect the percentage of permits issued for each county and distributed evenly from 2009 to 2019. We selected the subset for a larger 10-year time span, rather than the 2011-2016 period used for all permits, for a wider representation of permitting in the study area.

The 2011, 2013, and 2016 datasets were obtained from the USACE database as .csv files intended for detailed Freedom of Information Act (FoIA) reporting. They include information about every permit and impact the USACE authorizes in a year including acres of authorized fill, impact type, name of the project, and two types of location coordinates for the project: location of the wetland and the location of the project.

The subset of permit files from the USACE database were reviewed by looking at the actual permit document to analyze the specific types of temporary impacts authorized in each land cover type. Each of the permit files describe the impacts authorized along with conditions of the permit. Some files also contain engineering drawings of the impacts to the wetlands. From all permits issued by the USACE District from 2009 and 2019, we selected 165 permits by county.

They approximately represent the permitting tendencies of the District as distributed by county (Appendix 4A). The location of each project was found within the permit itself and corresponds to the impact location. Each location was manually verified using high resolution imagery in Google Earth.

For the larger datasets from 2011, 2013, and 2016, we used the location of the wetland being impacted by the project. The wetland location roughly corresponds to where the impacts to the wetland occur in each project, so it is the best approximation available for the location of impacts to aquatic resources.

The larger dataset had a few inconsistencies that were removed. For example, wetland locations outside the District boundaries were removed from the analysis. Although nearly all projects had wetland location data, some only had project location data. For those projects, the project location data was used as the best available approximation of the location of wetlands to aquatic resources.

Land cover data

To analyze impacts to aquatic resources in varying land covers, we used the National Land Cover Database (NLCD, https://www.mrlc.gov/data). The NLCD has 16 types of land cover at 30 by 30m resolution across the continental U.S. plus Alaska (Table 4.1). The 16 types of land cover data are based on a modified Anderson Level II classification system (Anderson 1976). The land cover data were produced by various U.S. government agencies roughly every 3 years, from 2001 to 2016. The NLCD uses Landsat remote sensing images and cloud detection as its basis for the 30 by 30 m resolution images. Then the database is created using a series of algorithms, models, and training data (Jin et al. 2019). The NLCD has been extensively analyzed for accuracy and the development of the database is well documented (Jin et al. 2019; Homer et al. 2020; Homer et al. 2004; Homer et al. 2015; Yang et al. 2018). This land cover data was selected as it covers our entire study area and should this study be done in another USACE District, the same dataset could be used.

For the detailed permit analysis, we used NLCD data from the year the permit was issued up until the year before the next NLCD year (i.e., permit years 2011 and 2012 for NLCD 2011; 2013, 2014, and 2015 for NLCD 2013; and 2016, 2017, 2018 and 2019 for NLCD 2016). In this way, we linked land cover data that was a good approximation of what the land would have looked like at the time of the initial processing of the permit, since the date associated with the permit is the date the permit was finalized and given to the applicant. To calculate the NLCD land cover classification for both the detailed permits and the overall USACE data, we used ArcMap to calculate the majority land cover type within a 500 m buffer around the impact location (Figure 4.1). We used a 500-meter buffer to assess the surrounding land cover type more broadly, rather than selecting a buffer size as large as the pixel (30 meters). This buffer size has been previously determined to be a good size for water quality impacts and land cover surrounding roads (Johnson and Belitz 2009; Nieszała and Klich 2021).

After initial land cover analyses, we condensed the 16 categories into four general land cover categories: Developed Lands, Natural Lands, Open Water, and Working Lands (Table 4.1). We compared permanent and temporary impacts, types of impacts, amount of authorized fill, and other factors over time and amongst the four different land use categories. Additionally, we separated out large linear projects for some of the analyses. To understand what proportion of the overall permitted impacts to wetlands were caused by linear projects, we separated out projects with greater than 100 impacts to wetlands, a total of six projects.

RESULTS

Types of temporary impacts to wetlands and land cover

Temporary impacts to wetlands within the detailed permit analysis were mostly due to construction; a total of 101 of the permits had impacts related to construction (4.2. Sediment removal was second most common (38 total), bank stabilization (19 total), followed by water diversion (15 total), restoration (14 total), and dewatering (8 total). The remaining impact types were not frequent within the dataset, representing less than five permits. Types of temporary impacts more frequent in natural lands included construction (51), restoration (6), and sediment removal (22). Dewatering (6), grading (2), and water diversion (11) were more frequent in developed land than natural land. Bank stabilization impacts were seen in equal amounts, 8 times each, in both natural and developed lands. Temporary impacts within working lands were only for construction (4), restoration (2), bank stabilization (2) and sediment removal (1) impacts. Near open water temporary impacts to wetlands were only seen in bank stabilization, construction, dewatering, restoration, and sediment removal once each.

Trends over time and frequency

Permits issued within the entire District in 2011, 2013, and 2016 show similar patterns of temporary impact locations over time (Figure 4.1). Most projects are located near the coastal and developed regions of California and Arizona. Although some projects occurred in medium and high density developed areas, many occurred on the outskirts of densely developed land, either in low-density areas or undeveloped areas. This pattern can be seen in Tucson, AZ, with temporary impacts to wetlands occurring on the outskirts of the city center. Many of the projects occurring outside of developed regions were linear projects, visible as wetland impact locations in a line on the maps, discussed further below. These visual trends are consistent in all years.

In 2011, 2013, and 2016, the number of temporary and permanent impacts to wetlands were both primarily located in natural lands (Figure 4.3). Over the years we see similar patterns and no temporal trend. After natural lands, by far the most common location overall, permanent and temporary impacts were more frequent in developed lands, with few located in open water or working lands. However, the hectares of impacts, both permanent and temporary, show fluctuation over time with particularly large hectares in natural lands in 2013 for permanent impacts and developed land in 2016 for temporary impacts (Table 4.2). Hectare totals within the study area were heavily influenced by a few large projects. In 2013, 972 hectares of permanent impacts can be attributed to a permanent change in wetland type for a restoration project located near the Salton Sea, in natural land. In 2016 there was a large spike in temporary impacts due to one project with 1,299 hectares of temporary impacts for sediment and vegetation clearing of concrete-lined channels located in developed lands.

Overall, in all years and land cover types, most impacts were smaller than 0.1 acres or 0.04 hectares. In all years and for both permanent and temporary impacts to wetlands, developed lands had impacts that were mostly between 0.01 and 0.1 acre (0.004 and 0.04 hectare) (Figure 4.4). In natural lands in 2011, 2013, and 2016, temporary impacts were even smaller, mostly between 0.001 and 0.01 acre (0.0004 and 0.004 hectare). In 2011, permanent impacts to wetlands were also primarily between 0.001 and 0.01 acre (0.0004 and 0.004 hectare). In 2013 and 2016 permanent impacts to wetlands were mostly 0.001 and 0.01 acre (0.0004 and 0.004 hectare) for developed and natural lands.

Linear impacts to wetlands and land cover

Linear projects, such as power lines or long roads, account for a large portion of the numbers of impacts to wetlands, but few hectares of impacts. Of permanent impacts authorized by the District, linear projects comprised most impacts in natural lands in 2011 and much of the impacts in natural lands in 2013 and 2016 (Figure 4.5). Of temporary impacts authorized by the District, linear projects again made up many impacts to natural lands in 2011, 2013, and 2016. Yet linear projects made up less than 1.6 hectares of the over 1,300 total hectares of authorized permanent impacts to wetlands and less than 1.2 hectares of the over 2,600 total hectares of temporary impacts to wetlands within our dataset (Table 4.2)

DISCUSSION

Given the declining wetlands in the U.S. and continued pressures due to human activities and climate change, our study exploring temporary impacts to wetlands highlights their numerous, yet individually small, impacts to wetlands in natural lands in the arid southwest. The location of the impacts to wetlands around highly developed regions is similar to what researchers have found with permanent impacts to wetlands elsewhere in the United States. (Brody et al. 2008; Goldberg and Reiss 2016; Kentula et al. 1992). Additionally, the notably small hectares of impacts attributed to linear projects and to most of the other types of impacts indicate that most impacts would not be compensated by the USACE compensatory mitigation requirements (U.S. Army Corps of Engineers 2008).

Types of temporary impacts to wetlands varied according to the category of land in which the project occurred. Impacts associated specifically with construction were high in natural, developed, and working lands. Open water land cover types were not common within the dataset, with only five temporary impact types occurring in open water areas. Temporary impacts dealing with moving water, either by dewatering or water diversion, occurred more in developed lands than any other land cover type. This may be due to the constraints of working in wetlands in developed areas. Urban runoff and increased impervious surface coverage in developed lands can cause increase flows in rivers and streams (Walsh et al. 2012; Sterling et al. 2013). Thus, even doing work in wetlands during a dry season in the arid southwestern U.S. may require dewatering or water diversion in developed land due to anthropogenically increased flows.

We found that many temporary impacts to wetlands were located in highly developed coastal regions of southern California and in the areas surrounding the Tucson and Phoenix metropolitan areas in Arizona (Figure 4.1). This trend of impacts to wetlands in and around growing metropolitan regions has been seen by other researchers as well, although they focused on permanent impacts to wetlands or loss. In Texas and Florida from 1991-2003, impacts from Section 404 permits were primarily seen along the coast in and around major metropolitan centers (Brody et al. 2008). Similarly, in the 1980's and 1990's, Oregon and Washington saw most permitted impacts to wetlands occurring in the vicinity of urban centers (Kentula et al. 1992). An analysis of wetland loss and mitigation in northeast Florida from 2006 – 2013 found again that the wetland impacts were occurring due to urban development (Goldberg and Reiss 2016). Impacts to wetlands are one of the main indicators of urban sprawl (Hasse and Lathrop 2003). Urban sprawl has been linked to habitat fragmentation, loss of natural wetlands, increased invasive species, and decline in biodiversity (Hasse and Lathrop 2003; Irwin and Bockstael 2007; Liu et al. 2003; Radeloff et al. 2005). Sprawl is typically linked to poor planning, distance between employment and residential dwellings, and/or local zoning policies (Galster et al. 2001; Wassmer 2008). Some research indicates that urban sprawl is partially due to developers avoiding regulated wetlands (Gnagey 2018).

In 2011, 2013, and 2016, hectares of permanent and temporary impacts did not show any trend and were heavily weighted by two specific projects. Additionally, our results show that both temporary and permanent impacts to wetlands were frequently less than 0.1 acre or 0.04

hectare. Although permitted impacts to wetlands do not account for the habitat loss in the surrounding area (Swenson and Ambrose 2007; Kelly 2001), the USACE is authorizing projects under Section 404 of the CWA that are resulting individually in very small impacts to wetlands. It is possible the small size of most impacts to wetlands may be a deliberate effort on the part of the permittees to avoid the financial burdens of compensatory mitigation. It also may be that the USACE efforts to minimize impacts to wetlands are successful for the majority of projects, and thus most impacts to wetlands within this District are less than 0.1 acre.

Linear projects account for many of the impacts to wetlands in natural lands, but very few of the hectares of impacts. Their location in natural lands, and the fact that you can see these projects as dots in a rough line on the maps, speaks to the nature of these projects. Most of them are utility line or transportation projects. In 2011, 2013, and 2016 there were several exceedingly long projects with hundreds of impacts to wetlands. Three of the long, linear projects were transmission lines, two were roads, and one was a fiber optic cable. Increasing reliance on renewable energy resources may lead to increasing reliance on transmission lines to carry the energy to where it is needed (Zhou et al. 2011). Should California reach its goal of 100% renewable energy by 2045 and given that the state does not have uniformly distributed wind and solar potential across the whole state, new transmission lines will be necessary to connect major producing regions to the high energy demand regions (Long et al. 2020). This will likely be a growing type of temporary impact in the southwestern U.S. region impacting natural lands more than any other type of land cover. Research has shown the potential for negative impacts to birds and bats, increased habitat fragmentation, and increased invasive species from increasing renewable energy development and related infrastructure (Jenkins et al. 2010; Kuvlesky et al.

2007; Loss et al. 2014). However, hectares of permanent and temporary impacts to wetlands by long linear projects are relatively low compared to non-linear impacts in the District.

Although the focus of this research was temporary impacts, the permanent impacts to wetlands showed similar trends in that most were less than 0.4 hectares and located in natural lands. Given the small size of most impacts, compensatory mitigation would not be a regulatory tool used for restoration of these impacts. Another option to ensure these impacts are restored could be voluntary restoration, which some research shows plays a key role in mitigative wetland loss (Gittman et al. 2019). But that would not be enforceable under any current USACE policies.

Given the increasing population and development in this study area knowing where impacts have been occurring for the past decade can help other levels of government, non-profits, and others focus conservation efforts. Sustained development in the arid southwestern U.S. as well as climate change indicate that wetlands in this region will continue to be under pressure. By understanding where wetlands are being impacted and the nature of those impacts, we can better understand where to focus conservation efforts.

Tables

Table 4.1: Four categories of land cover and NLCD developed categories.

Developed Lands	**Working Lands**	**Natural Lands**	**Open Water**
Developed, Open Space	Cultivated Crops	Evergreen Forest	Open Water
Developed, Low Intensity	Pasture-Hay	Mixed Forest	
Developed, Medium Intensity		Shrub/Scrub	
Developed, High Intensity		Grassland/Herbaceous	
		Woody Wetlands	
		Emergent Herbaceous Wetlands	
		Barren Land	

Table 4.2: Permanent and temporary hectares of impacts to wetlands in different land cover types by non-linear and linear projects

		Permanent Hectares of Impact to Wetlands		**Temporary Hectares of Impact to Wetlands**	
		Non-linear	**Linear**	**Non-linear**	**Linear**
2011	Developed Land	72.04	0.01	30.81	0.0004
	Natural Land	70.09	1.50	47.73	0.89
	Open Water	0.58		8.70	
	Working Land	1.02		4.98	
2013	Developed Land	6.92		116.17	
	Natural Land	1032.91	0.07	18.55	
	Open Water	5.15		3.01	
	Working Land	0.78		1.66	
2016	Developed Land	4.61	0.003	1328.41	0.001
	Natural Land	10.47	0.50	51.85	0.50
	Open Water	124.10		4.02	
	Working Land	0.09		14.24	

Figures

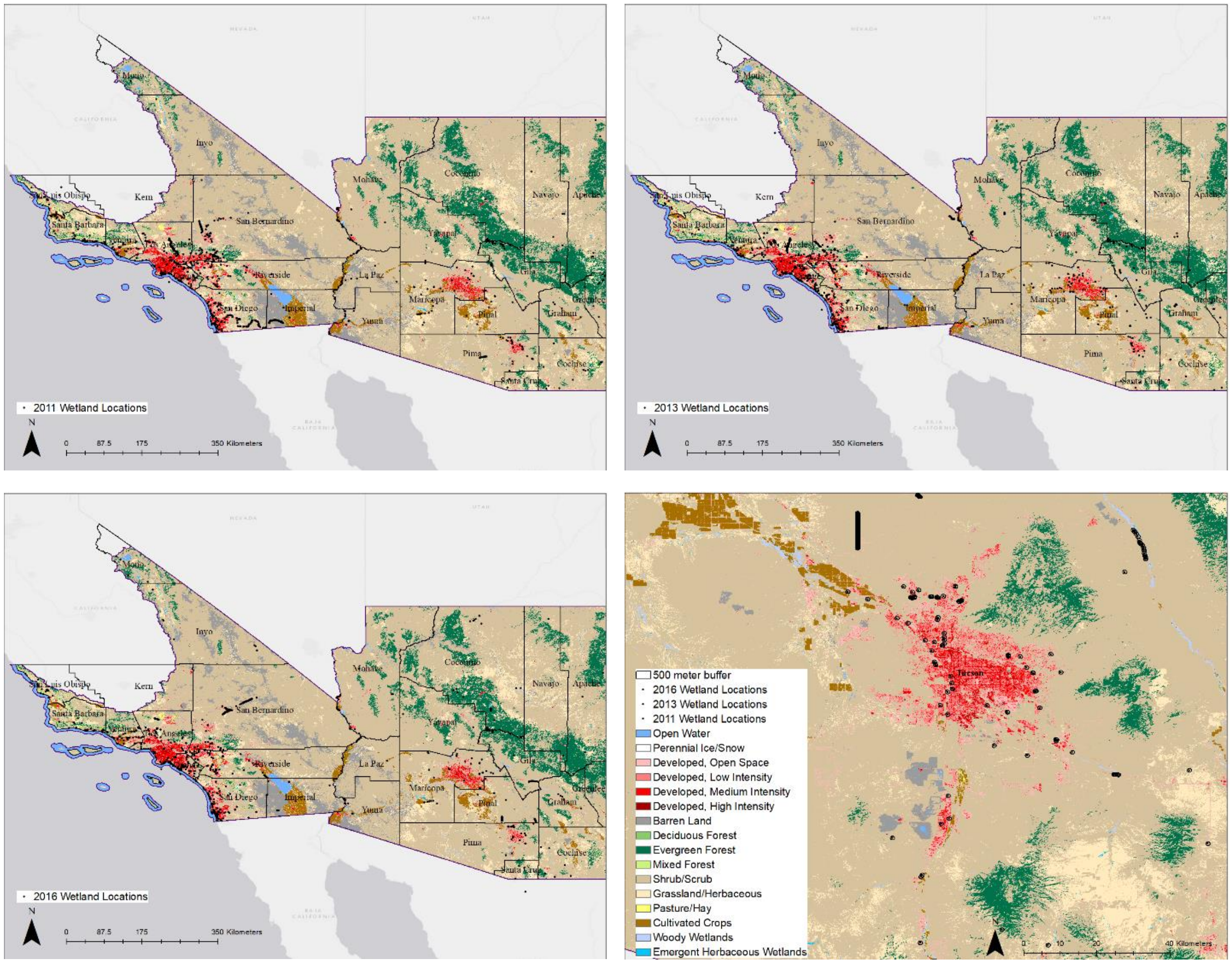


Figure 4.1: Locations of temporary impacts to wetlands, approximated using wetland location data, authorized by the District in 2011, 2013, and 2016, and a close up of the Tucson area with 500-meter buffers for all years (2011, 2013, and 2016) wetland locations.

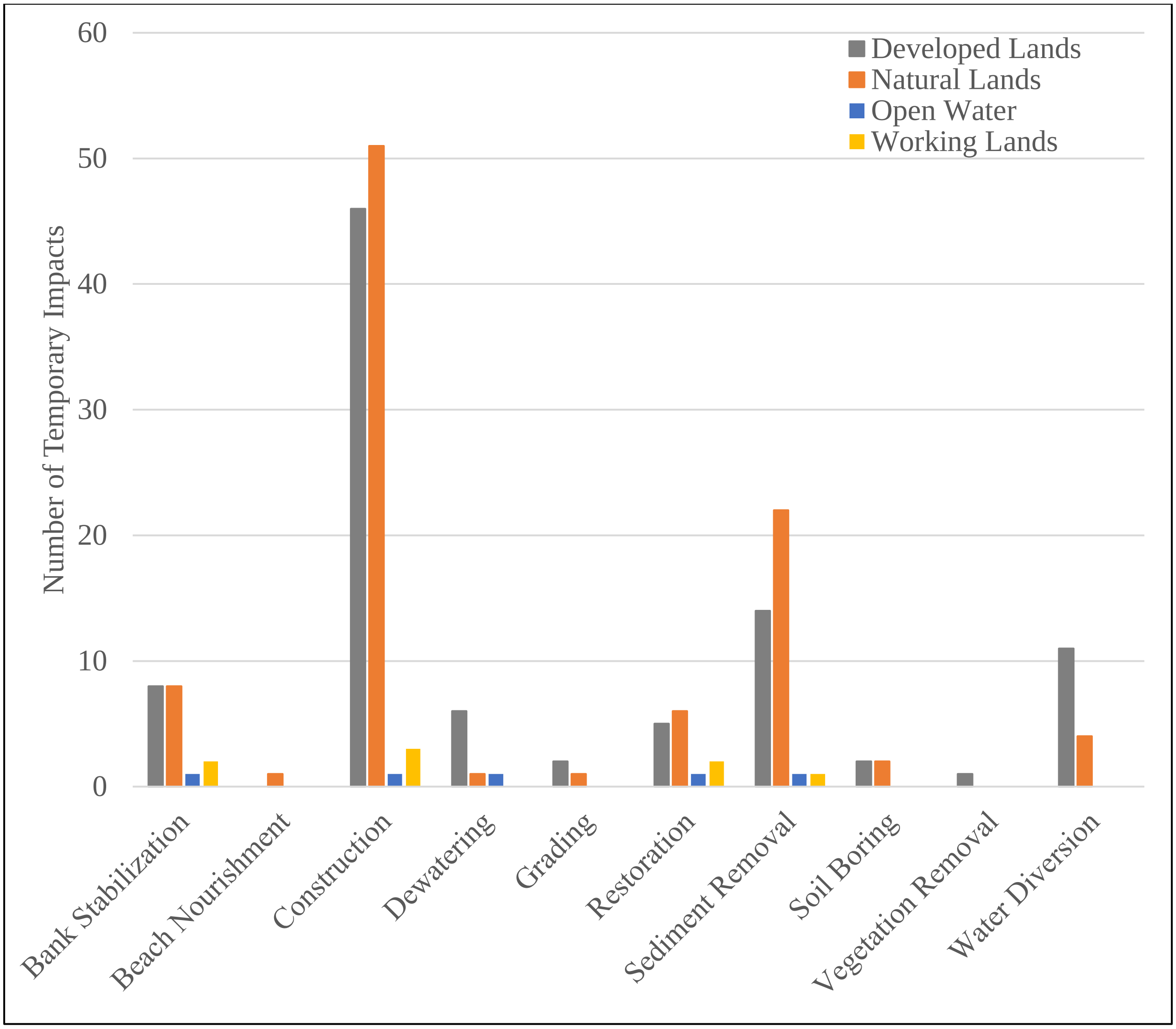


Figure 4.2: Number of temporary impacts per type of impact. Total number of permits analyzed is 165, but total impacts are greater than 165 because many permits had multiple types of temporary impacts.

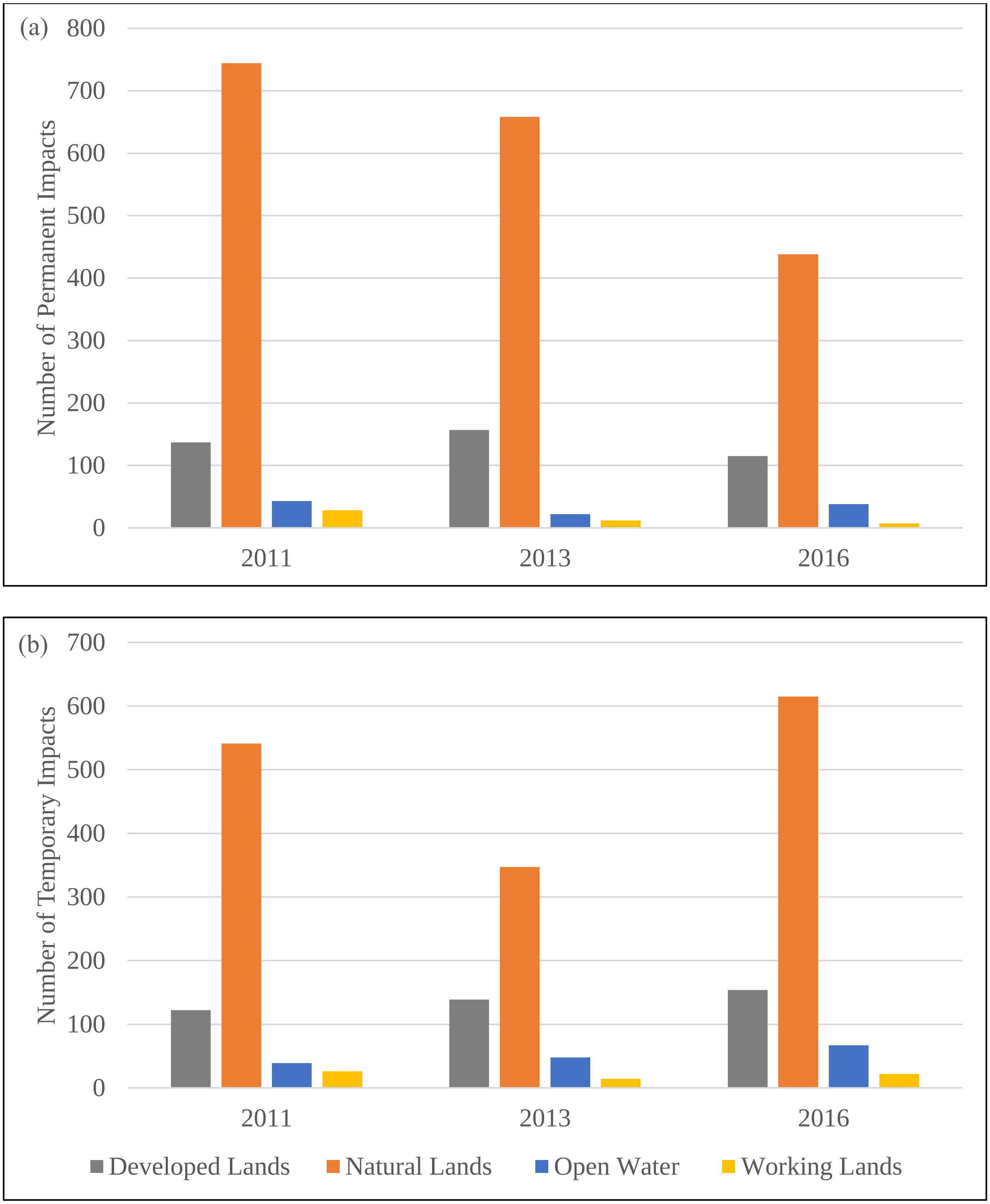


Figure 4.3: Number of (a) permanent and (b) temporary impacts to wetlands permitted by the District in 2011, 2013, and 2016 by land cover.

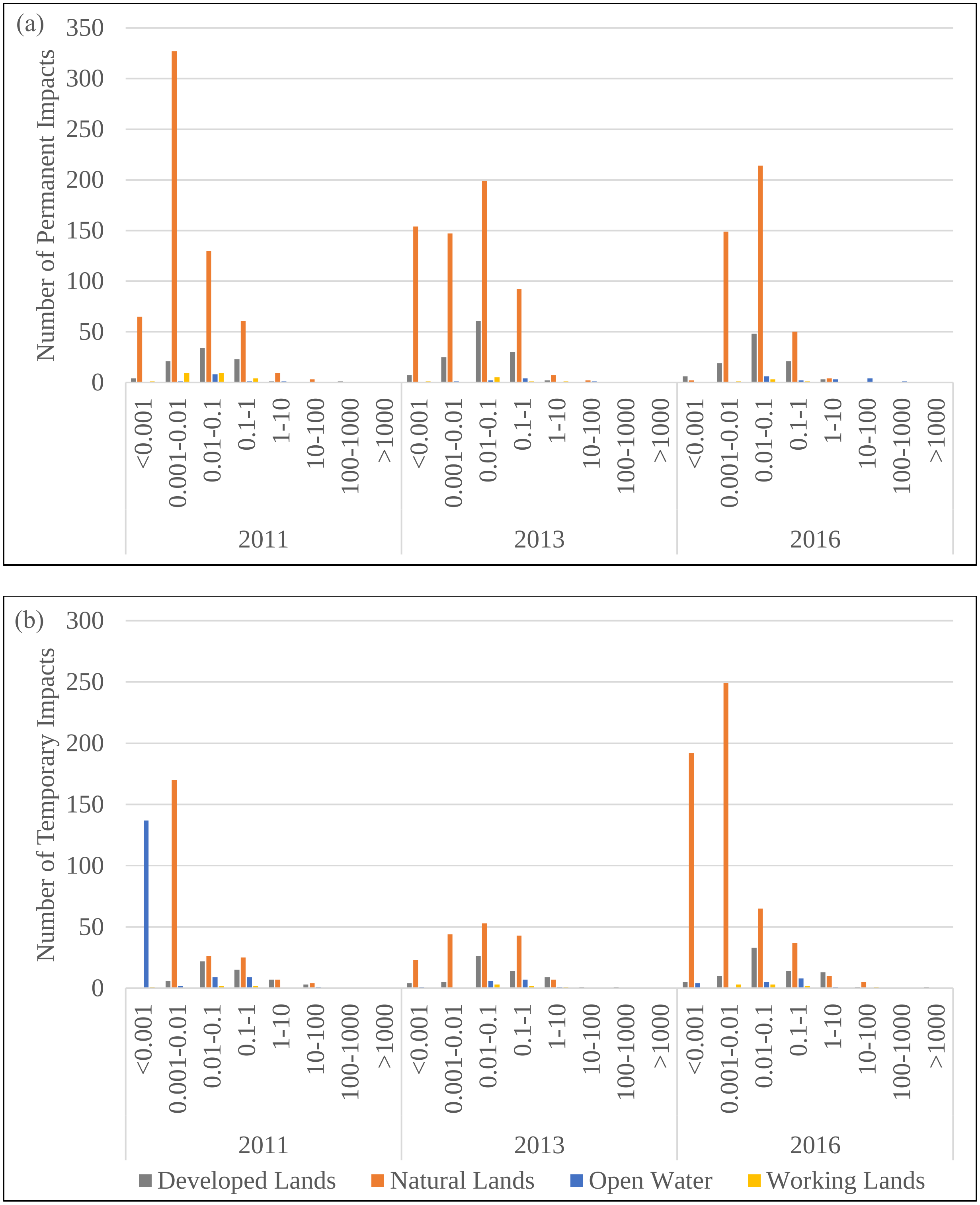


Figure 4.4: Frequency of impact in acres for (a) permanent and (b) temporary permitted acres of impact in 2011, 2013, and 2016.

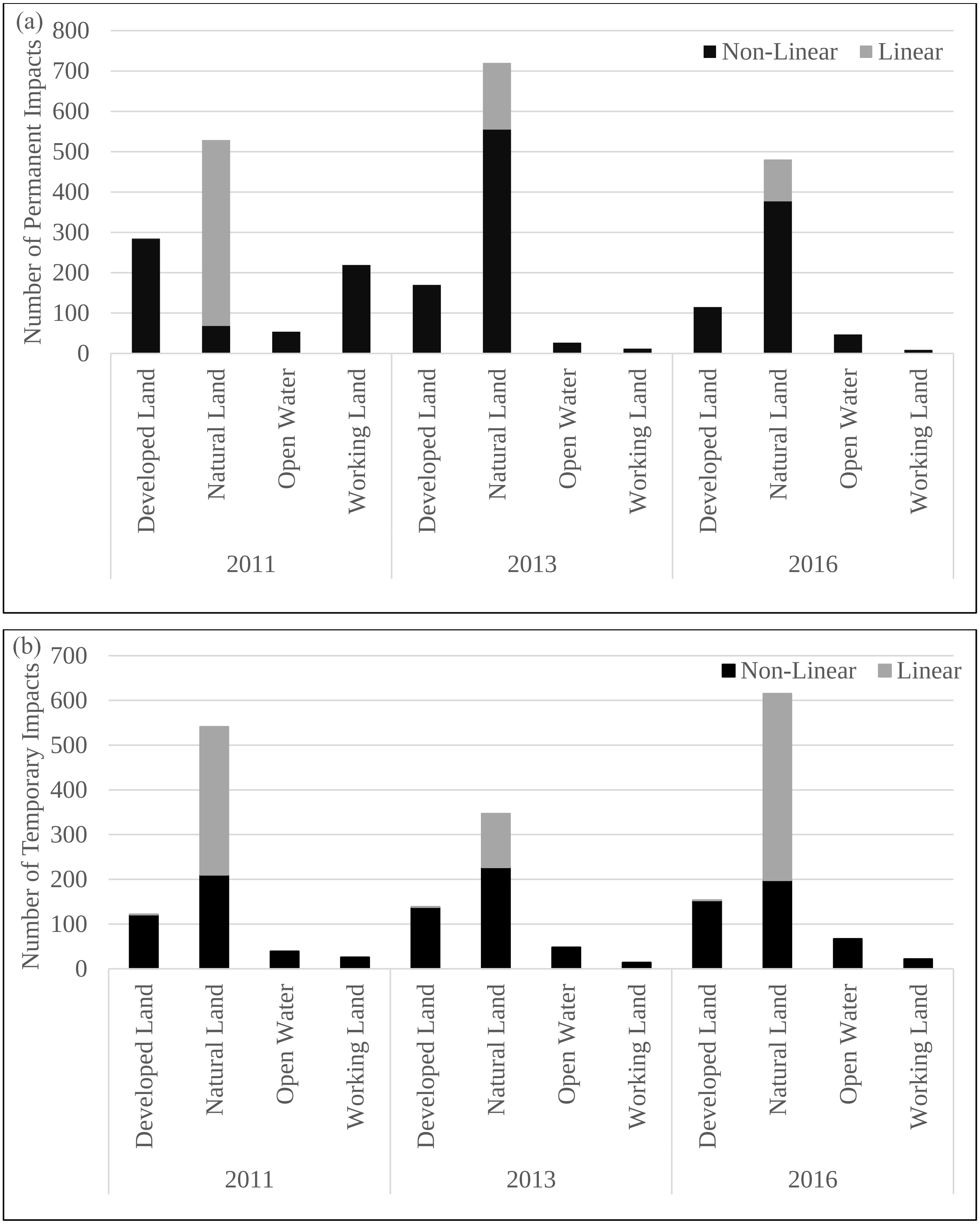


Figure 4.5: Number of (a) permanent and (b) temporary impacts authorized in the District in 2011, 2013, and 2016, by land cover with linear projects with greater than 100 impact locations in grey.

Appendix 4A: Population data and temporary impacts authorized by county

Appendix 4A.1: Permits authorized by the District for temporary impacts to wetlands from 2009 to 2019, total permits, population in each county in 2010 and 2019, and percentage population growth from 2010 to 2019. Ordered by percent population growth. All population data obtained from the U.S. Census (census.gov/data).

County	2009	2011	2013	2015	2017	2019	Total 2009 - 2019	Pop. 2010	Pop. 2019	Percent Population Growth
Pinal	0	3	4	2	2	1	18	375,764	462,789	23.2
Maricopa	4	7	31	5	46	1	139	3,817,365	4,485,414	17.5
Riverside	7	27	19	17	30	34	244	2,189,765	2,470,546	12.8
Greenlee	1	0	2	0	0	0	5	8,444	9,498	12.5
Yavapai	2	1	1	3	3	1	21	211,017	235,099	11.4
Yuma	1	2	3	0	7	3	31	195,750	213,787	9.2
San Diego	22	46	45	43	49	55	480	3,095,349	3,338,330	7.8
Kern	0	1	2	0	0	0	6	839,621	900,202	7.2
San	17	79	34	51	50	44	453	2,035,183	2,180,085	7.1
Pima	4	7	6	14	5	7	74	980,263	1,047,279	6.8
Coconino	2	0	1	2	2	3	18	134,426	143,476	6.7
Mohave	2	6	5	2	14	15	90	200,182	212,181	6
Orange	37	48	62	52	85	60	589	3,008,989	3,175,692	5.5
Santa	9	27	12	27	36	24	269	423,947	446,499	5.3
San Luis	8	14	9	11	15	11	117	269,597	283,111	5
Graham	1	1	1	0	0	0	8	37,212	38,837	4.4
Imperial	3	4	1	1	2	1	29	174,524	181,215	3.8
Navajo	2	2	1	0	2	1	12	107,488	110,924	3.2
La Paz	0	5	4	1	10	11	50	20,489	21,108	3
Ventura	14	26	15	17	16	22	184	823,398	846,006	2.7
Los Angeles	46	47	48	76	52	54	565	9,819,968	10,039,107	2.2
Mono	1	1	2	0	2	2	21	14,206	14,444	1.7
Gila	1	2	4	1	4	2	26	53,592	54,018	0.8
Apache	2	2	1	1	3	2	19	71,517	71,887	0.5
Santa Cruz	0	0	4	1	2	1	18	47,420	46,498	-1.9
Inyo	1	2	0	3	4	2	26	18,542	18,039	-2.7
Cochise	1	0	1	9	0	1	24	131,359	125,922	-4.1

CHAPTER FIVE: CONCLUSION

Discussion of Results

Wetlands are valuable ecosystems protected by a variety of state and federal laws. Section 404 of the Clean Water Act (CWA) is the primary federal law that charges the U.S. Army Corps of Engineers (USACE) with regulating impacts to wetlands. While researchers have looked at compensatory mitigation and permanent loss of wetlands, little is known about temporary impacts to wetlands permitted under Section 404 of the CWA. This dissertation examined several aspects of temporary impacts to wetlands permitted under Section 404 of the CWA. We started with an analysis of the nature and extent of temporary impacts within the arid southwestern U.S. This highlighted hundreds to thousands of temporary impacts authorized each year, making them as common, or even more common in some years, as permanent impacts to wetlands within the Los Angeles District (District). Each year in our dataset between 70 and 1,500 hectares of temporary impacts were authorized; in eight of the 11 years the hectares of authorized temporary impact were greater than the permanent impact. To understand whether these temporary impacts were recovering to pre-project conditions, as they are required to by the USACE guidance (U.S. Army Corps of Engineers 2015), we then used high resolution imagery to analyze the temporary impact site using the aerial imagery assessment method (AIAM) and percent vegetation cover. Vegetation cover did not make a full recovery in 40% of our sites; and many AIAM metrics did not fully recover to pre-impact levels, only recovered slightly, or took many years to fully recover. Finally, we identified land cover surrounding authorized temporary impacts to wetlands from 2009 – 2019. Between 63% and 74% of temporary impacts permitted each year were in natural lands, although hectares of temporary impacts varied and were dominated by two individual projects one in natural and the other in developed lands. In all years, many temporary impacts were located on the edge of developing and expanding urban areas. Impacts less than 0.04 ha (0.1 acre) were the most frequent in every land cover type and in every year.

There has been concern about wetland loss and adequate protection and restoration of wetlands in the U.S. for many decades (Race 1985; Race and Fonseca 1996). Researchers and policymakers have primarily focused on compensatory mitigation and permanent wetland loss rather than temporary impacts. Yet even for compensatory mitigation, which has a lot of attention from conservationists and regulators, there are areas within the U.S. where the required compensatory mitigation has been less than allowed impacts (Duncan et al. 2018; Kentula et al. 1992; Sudol and Ambrose 2002). Although imperfect, compensatory mitigation efforts historically have been tweaked and changed in an attempt to improve protection and compensation for wetland loss in the U.S. (Hough and Robertson 2009). But this focus on improving wetland protection by researchers and regulatory policy has ignored temporary impacts to wetlands. Temporary impacts are not widely assessed or reported by researchers or the USACE. This dissertation worked towards understanding how temporary impacts were impacting wetlands in the arid southwestern U.S., and if wetlands were recovering from the effects of the temporary impacts. Prior to this study, Ambrose et al. analyzed 143 projects requiring compensatory mitigation throughout California and found that 51 acres of wetlands were impacted temporarily compared with 166 acres of permanent impacts (Ambrose et al. 2006). Although that study found three times more acres of permanent impacts than temporary impacts, it only included permits requiring compensatory mitigation, so permits with only temporary impacts would have been excluded from the study, resulting in a disproportionate occurrence of permanent impacts. As no other researchers have discussed temporary impacts to wetlands in this region, and the USACE does not author reports on temporary impacts, this dissertation provides the best information available on temporary impacts in the arid southwestern U.S.

From 2009 to 2019, temporary impacts generally exceeded permanent impacts in hectares of impacts to wetlands, contrary to what Ambrose et al. found in their review (Ambrose et al. 2006). Since they only included permits requiring compensatory mitigation, it is reasonable to expect that temporary impacts would be more prevalent among all permits. Our detailed permit analysis revealed that, although 94% of permits with temporary impacts had a condition that the impacts be restored to pre-construction conditions, monitoring of that restoration and recovery was only required in 20% of the permits. Since restoration of streams and wetlands is not always successful (Bernhardt et al. 2007), the lack of monitoring creates uncertainty in the regulatory process as to whether these temporary impacts are being returned to pre-project conditions.

In AIAM and vegetation cover analysis, we found that several projects did not recover to pre-impact conditions, but not all metrics had the same response. Vegetation cover did not fully return to pre-project conditions within our maximum time frame of nine years in 40% of our dataset. Water Source, Average Riparian Zone Width, Lateral Hydrologic Connectivity, and Percent Tree and Shrub Cover were sub-metrics of AIAM that had at least 50% of sites with no effect from the temporary impact. Some of these sub-metrics are not anticipated to be impacted by temporary impacts, such as Water Source or Lateral Hydrologic Connectivity. Average Riparian Zone Width and Percent Tree and Shrub Cover sites with no impacts may be due to the nature of the temporary impact, which can often occur just in one small area on one side of the full AIAM assessment area. Four of the six sub-metrics had at least one site that was impacted and never recovered, not even slightly, in all years of analysis. Additionally, four of the six sub-metrics had at least one site that only slightly recovered, never making a full recovery within all years of analysis. Evidence of Channel Alteration and Vegetation Development saw the most fully recovered sites of all AIAM sub-metrics. Our results are in line with what Fong found when developing AIAM and the predictions for anticipated restoration responses (Fong 2015). Fong anticipated that Water Source and Lateral Hydrologic Connectivity would have no response to restoration effects and that Average Riparian Zone Width would increase, Evidence of Channel Alteration would decrease, Vegetation Development would mature over time, and that Percent Tree and Shrub Cover would increase in cover area. Although restoration is not the same as temporary impact recovery, general or special conditions in the permit do require returning a wetland area to its prior conditions before disruption or degradation.

We found that vegetation cover recovery post-temporary impact was slightly worse for sites in natural lands than in developed lands, working lands, or open water. This could be due to increased impervious surface and runoff increasing dry weather flows in developed waterways (Walsh et al. 2012; Sterling et al. 2013). While this increase in flows appears to help vegetation recovery, it also necessitates some types of temporary impacts in the first place. We found certain impacts such as water diversion and dewatering more common in developed lands than natural lands. If work is occurring during the dry season in a developed land in the arid southwestern U.S., it may have dry-weather flows due to runoff from the surrounding developed land and thus require water diversion or dewatering measures that impact the waterway further when the same work in natural lands would not have had that impact.

Policy Implications and Recommendations

Measuring wetland response and recovery using aerial imagery alone is a start to understanding temporary impact recovery as it allowed us to quickly analyze many sites over many years, but it is not a substitute for field-based monitoring. In the absence of field-based monitoring, particularly because 80% of USACE permitted temporary impacts within our dataset had no monitoring requirement, using AIAM allowed us to observe hydrologic and vegetation structure recovery remotely. It also allowed us to monitor before, during, and after the temporary impact to the wetland; unless monitoring is required before a project's impact, it is extremely difficult to obtain before-project data without using remotely sensed information. As monitoring is essential to evaluate recovery and restoration (Palmer et al. 2007) and time-consuming studies are not always possible or practical, remote sensing methods like AIAM would be a good option for the USACE to use to monitor temporary impact recovery, or to accept as a method of monitoring from their permittees. Allowing a remote sensing monitoring method, would save permittees time and money. However, remote sensing data are limited to the available images, usually collected by another entity and often not at the times desired, unless the permittee or the USACE was able to use an unmanned aerial vehicle (UAV) to collect current, high-resolution imagery of the wetland. With the increasing adoption of UAVs in ecological data collection (Anderson and Gaston 2013; Sankey et al. 2018), this option is increasingly attractive.

Within our dataset, no temporal trend emerged for temporary impacts within the study area, although in the future there could be an increase of linear projects within the southwestern U.S. Long, linear projects unexpectedly accounted for many of the impacts in natural lands, but few of the hectares of impacts. However, none of these impacts were selected for review using AIAM or vegetation cover as each impact location was too small to accurately assess using available imagery. Therefore, we do not know how they are recovering. California will likely need more transmission lines to connect renewable energy producing regions with high energy demand regions (Long et al. 2020). These projects should all be required to provide a post-project temporary impact recovery report to demonstrate their temporary impacts to wetlands are fully recovering and not resulting in hundreds of small permanent impacts to wetlands in this District.

A large temporary impact in developed land occurred in 2016: a single sediment removal project in Los Angeles County. This project and other sediment removal projects were the second most common type of temporary impact within our dataset and are a result of flood management infrastructure that constantly needs to be maintained to ensure flood capacity (Greco and Larsen 2014; Lassettre and Kondolf 2012; Liao 2014). Concurrently, we found that most of our selected permits were issued to public entities, rather than developers as was found by Ambrose et al., who only selected projects that required compensatory mitigation (Ambrose et al. 2006). As most flood management infrastructure is controlled by public entities, this finding makes sense. This highlights a key distinction between temporary and permanent impacts and brings to light a question of what counts as a temporary impact. Is a temporary impact truly temporary if that same channel would be impacted again in five years because it functions as flood management infrastructure? The current definition of temporary impacts per the regulations and regional guidance would seem to allow it (U.S. Army Corps of Engineers 2015) provided the wetland can recover to pre-impact conditions before being impacted again. A better solution would be to consider this frequent, on-going maintenance, as a permanent impact that would be offset with compensatory mitigation. This is currently happening within the Los Angeles District, but not on a uniform basis with all channels that serve in a flood management capacity. A few projects in our dataset from Chapter 2 were required to compensate for their sediment removal impacts but most were not; however, our dataset was a small sampling of the permits issued within this District and further research should focus on this type of temporary impact. Furthermore, in the USACE database and reporting system, the temporary impacts to the flood control channels are still counted when the permit is re-issued in 5-10 years, the length of many permits. Subsequent permits for sediment removal temporary impacts should be treated as a renewal and not count as a permanent or temporary impact within the USACE database to avoid inflating the number and hectares of temporary impacts of this nature.

Under the current system, the logic of authorizing temporary impacts to wetlands is that they would be returned to pre-project conditions within some (assumingly short) timeframe after the project. There are several flaws with this, illuminated by the results of our studies. First, there is no actual time frame for recovery in the regulations. Within our dataset, the sites that made a full recovery had widely varying times to recovery, during which time they were resource losses. For example, sites that did not recover until six years post-construction, would have six years of degraded function within that system. Additionally, the sheer number of temporary impacts within the arid southwestern U.S. is high. Specifically, the natural areas on the outskirts of city centers should be carefully considered by the USACE as their landscapes transition from natural to developed and they see an increase in impacts to wetlands. Since impacts permitted by the USACE do not account for the additional habitat loss surrounding the area (Stein and Ambrose 1998), these impacts are likely creating more hectares of impacts than recorded by the USACE, making it even more important that they are actually temporary and not permanent. Finally, having any temporary impact not make a full recovery means it is not temporary and should be treated by the USACE as permanent. This could be determined with a monitoring report requirement for every permit with temporary impacts or a desk AIAM analysis of the site using aerial imagery. Then the USACE would be able to accurately assess whether the impact was temporary or if it is a permanent impact with the additional regulatory consequences. The Los

Angeles District currently uses a similar method for eelgrass mitigation. Based on the National Oceanic and Atmospheric Administration (NOAA) California Eelgrass Mitigation Policy and Implementing Guidelines, which the USACE Los Angeles District follows, projects located in potential eelgrass habitat require before and after eelgrass monitoring and compensatory mitigation requirements would be determined after the project is complete and two years of monitoring have occurred (National Oceanic and Atmospheric Administration 2014).

The USACE needs to clarify the definition of temporary impacts by including a timeframe for recovery. Right now, different USACE Districts have different guidelines, and there is nothing in the regulations published in the Federal Register. For example, the Seattle District has regional conditions for all projects that specify if a temporary impact exceeds six months, they may require compensatory mitigation (U.S. Army Corps of Engineers, 2017). The Los Angeles District, the location of the study area for this dissertation, does not have a specified recovery time but in their compensatory mitigation ratio checklist for permanent impacts to wetlands, they require mitigation ratios to be increased by 0.05 for each month of delay between the impact and the mitigation. The compensatory mitigation ratio checklist is used to determine how many how many acres to mitigate to offset their impacts to wetlands. The definition of a temporary impact should be general, applicable over the entire U.S. I proposed the following definition: Temporary impacts to wetlands are impacts that occur for a short-duration and are returned to pre-project contours, elevations, and functionality within six months of the end of the project. By defining the time limit of a temporary impact, the USACE could then require mitigation for any temporary impact that is not returned to pre-project conditions within six months.

Six months would be consistent with the Seattle District's guidelines. However, many wetlands, especially with high vegetation development, would not fully recover within that timeframe. For those wetlands, an extensive restoration plan could be required with annual monitoring until fully recovered. That type of impact could be considered conditionally temporary, and the permit would not be considered in compliance until the applicant submitted the monitoring reports showing conditions were returned to pre-project conditions.

The U.S. EPA and the USACE share enforcement under CWA Section 404. Violations include failure to comply with the terms or conditions of a Section 404 permit. Therefore, the USACE should ensure the definition of a temporary impact, with either the six-month timeline or the restoration and monitoring conditions, is included in every permit for projects with temporary impacts to wetlands.

The relationship between USACE regulations and the location of impacts to wetlands may be in flux given changing regulations. The 2020 Navigable Water Protection Rule, which removed ephemeral streams as a regulated water, resulted in fewer regulated wetlands in the U.S. as a whole and specifically in the arid southwest (Fesenmyer et al. 2021; U.S. Army Corps of Engineers 2020). A 2008 report published by the U.S. Environmental Protection Agency found that 94% of streams in Arizona and 66% of streams in California are ephemeral and intermittent (Levick et al. 2008). A more recent analysis estimates 7.9 million km (48%) of stream channels in the U.S. are ephemeral (Fesenmyer et al. 2021). If the 2020 Navigable Waters Protection Rule stays in effect, fewer temporary and permanent impacts will be reported within the USACE databases in the arid southwestern U.S. This dissertation not only sheds more light on temporary impacts to wetlands, but also can serve as a baseline for the region. Researchers should continue to focus on temporary impacts to wetlands regardless of changes in federal jurisdiction, as the population and development in this region continues to increase, putting pressure on wetlands, especially on the outskirts of urban areas.

Further research should focus on state-level regulations and permits obtained for these types of projects. The Regional Water Quality Control Boards in California, the California Department of Fish and Wildlife, and the Arizona Department of Environmental Quality also issue permits regulating impacts to wetlands within California and Arizona. It is possible that these state agencies are already requiring mitigation or active restoration. They are not required to report their permitting requirements to the USACE and the USACE is not required to store their permits in any database. The results of this dissertation show that many of the temporary impacts to wetlands are not fully recovering, but they might have been mitigated for under a different law or policy, such as the Porter-Cologne Act of California. The next regulatory steps for ensuring temporary impacts to wetlands should include a new, enforced, definition of temporary impacts, and restoration plan guidelines to monitor temporary impacts that will not quickly recover to pre-project conditions.

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