Bicycling Impacts on National Wildlife Refuges

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The purpose of this white paper is to establish a common understanding of the state of the literature on cycling impacts to fish and wildlife, physical impacts on roads and trails, and maintenance and cost considerations to inform FWS stations in determining whether to allow bicycles on roads and/or trails within the Refuge. The paper continues with six case studies highlighting the varying circumstances of cycling on FWS refuges throughout the country and concludes with a Looking Forward section that summarizes the findings and identifies further research needs.

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Cover photo: Summer campers pedal through Chincoteague National Wildlife Refuge in Virginia. Credit: USFWS

Introduction

The U.S. Fish and Wildlife Service (FWS) has a stated objective to "Assist in the development and application of an environmental stewardship ethic for our society, based on ecological principles, scientific knowledge of fish and wildlife, and a sense of moral responsibility." This dedication to ecologic and scientific justifications for policies motivates FWS to understand the scientific basis for allowing or disallowing recreational activities in the National Wildlife Refuge System (NWRS).

The purpose of this white paper is to establish a common understanding of the state of the literature on bicycling impacts to fish and wildlife, physical impacts on roads and trails, and maintenance and cost considerations to inform FWS stations in determining whether to allow bicycles on roads and/or trails within the refuge. The paper continues with six case studies highlighting the varying circumstances of bicycling on FWS refuges throughout the country and concludes with a section that summarizes the findings and identifies further research needs.

Background

Of the over 560 national wildlife refuges, nearly 200 currently allow bicycling within their boundaries under a range of specified guidelines. Visitors enjoy bicycling at wildlife refuges for reasons that include seeing wildlife, being physically active, and photographing nature (**Error! Reference source not found.**). Allowing bicycling to a refuge or on a subset of refuge roads or trails has the potential to draw visitors who might not otherwise visit the refuge. In 2019, the NWRS had approximately 1.4 million bicycle visits on 197 national wildlife refuges.[1] Each station manager determines whether bicycling, or other recreational activity, is in line with the refuge's statutory purpose and is determined to be a compatible use.

Figure 1. Bikers follow a trail along the South Bay Salt Pond Restoration Project at Don Edwards San Francisco Bay National Wildlife Refuge (Photo: PelicanMedia)

There are countless varieties of bicycles, but some of those commonly seen in recreation contexts are highlighted in Table 1. Common Types of Recreational Bicycles

[1] https://www.fws.gov/refuges/biking/e-bikes.html

Table 1. Common Types of Recreational Bicycles

	**Road bikes**, which are typically lighter and are best used only on paved surfaces. These bikes may be ridden in from outside of the station and parked by visitor centers or trailheads or may be used on paved multi-use trails or roads within a station. (Photo source: USFWS)
	**Hybrid bikes**, which typically have flat handlebars like a mountain bike, but narrow tires like a road bike. These bikes are well suited on paved or light-duty caliche roads and dirt trails. (Photo source: DOI)
	**Mountain bikes**, which are heavier due to suspension forks and larger tires that typically have treads designed to give greater traction and stability on dirt or gravel trails. These bikes may be ridden to stations on roads or multi-use paved and unpaved trails. (Photo source: DOI)
	**Fat tire bikes**, which have even wider frames than mountain bikes that allow for extra wide tires that are more easily operated on snow, ice, and sand. These bikes can be ridden on any surface but can be laborious to ride long distances. (Photo source: Michigan DNR)
	**Electric bikes**, which can be any of the above types of bikes but with batteries and motors to allow electric power to either enhance the rider's efforts (electric assist bikes) or to fully propel the vehicle (full electric bikes). Some local and state regulations may limit how fast electric bikes may go on public roads or trails, although these vary widely. [2] (Photo source: BLM)

[2] The National Conference of State Legislatures. 2020. "State Electric Bicycle Laws | A Legislative Primer" https://www.ncsl.org/research/transportation/state-electric-bicycle-laws-a-legislative-primer.aspx

Use of Electric Bikes

In October 2020, FWS delivered new regulations to the Federal Register on the use of electric bicycles in the National Wildlife Refuge System. It allows managers to consider the use of e-bikes on any refuge road and trail where traditional bicycle use is allowed, provided it is consistent with a refuge's statutory purpose and is determined to be a compatible use.

This follows the 2019 announcement by DOI for the bureaus to develop consistent and clear e-bike policies for the lands they manage (Secretary's Order 3376).

Impact of Bicycling on Wildlife

This section summarizes some of the types of impacts to wildlife that researchers have theorized and observed. To date, studies on impacts of bicycling to every species of concern to the FWS do not exist, and station managers therefore make decisions based on their own experiences and understanding of local population needs and behavior.

Some general concepts of wildlife behavior ("ethology") may be useful to consider when planning for infrastructure at refuges and other stations. The field of ethology assumes evolutionary bases for behavior, although this does not imply that all animal behavior has ancient roots. Species need not have co-evolved with human-made vehicles to react to vehicles in a manner related to other selective pressures. For example, loud sounds, certain silhouettes, or (vehicular or passenger) emissions such as smells may disturb wildlife. Some of the justification for auto-tour routes at refuges is that personal vehicles can function similarly to blinds (also known as hides) used for hunting, photography, and wildlife observation. Vehicular motion does not resemble animal ambulation, and cars insulate passenger sounds (while emitting other sounds).

The mission of the FWS affirms the potential for humans to exist in healthy relationships with other species, but humans frequently behave as and are perceived as predators to other wildlife. Recent research examines the ecological concept of the "landscape of fear," a framework for studying how perceived potential for violence, competition, or disturbance changes animal behavior. [3,4] Important lessons from the "landscape of fear" model include the idea that animals have the ability to learn and can respond to differing levels of predation risk in an area, that the perception of risk can be quantified, and that the perception of risk can be altered. Fear has been found to be potent enough to exert selective pressure similar to direct predation; cautious wildlife has been observed spending more time observing predators, rather than grazing, ultimately resulting in decreased caloric intake and reduced rate of reproduction. Such landscapes of fear can be healthy and more balanced than those without predation, prompting some conservation managers to reintroduce predators into habitat where they have been extirpated by conflict (as at Gorongosa National Park in Mozambique) or other circumstances.[5]

[3] Laundre, Hernandez, & Ripple, 2010
[4] Ciuti, Northrup, Muhly, Simi, & Musiani, 2012
[5] Lunking, 2020

Indeed, studies show that humans can exert a strong disturbance effect, affecting such factors as latency to feed, vigilance, foraging time, number of feeding visits, and number of animals feeding together in a comparison of disturbances caused by humans, dogs, wolves, and bears.[6] Human disturbances can be indirect as well, as species changing behavior to avoid humans may become active during different times of day and come into contact or competition with species that otherwise occupy separate niches.[7] Hence, the mere fact of disturbance caused by human presence may not be entirely undesirable or incompatible with conservation goals at FWS stations, but should be seriously considered by conservation managers.

Taylor and Knight (2003) studied the responses of bison (*Bison bison*), mule deer (*Odocoileus hemionus*), and pronghorn antelope (*Antilocapra americana*) to the presence of hikers and mountain bikers by setting transects on and off trails, then measuring and comparing the distances at which animals demonstrated alert behavior, distances at which animals took flight, and the distances moved in flight.[8] Critically, the study examined recreationists passing tangentially by subject animals rather than attempting to see how closely they could be stalked before flushing, which should be a good model for visitors exhibiting appropriate wildlife viewing etiquette.[9] The study was undertaken at Antelope Island State Park in Utah, which today hosts paved and unpaved trails for people on foot, horseback, and bikes/e-bikes (although the study excludes equestrians from its scope).

Taylor and Knight documented responses in several different contexts (e.g., relative elevation of recreationist and animal, animal group size, etc.) and were able to draw out broad trends and species-specific variations. Animals responded most to recreationists travelling above them and least to those travelling below them, suggesting a consideration for trail placement. Taylor and Knight only compared the disturbances caused by people travelling off-trail and on-trail to mule deer (and not bison and pronghorn), finding that people travelling off-trail caused alert behavior at greater distances and caused the deer to move farther in flight.

While this study found little difference in wildlife response to hikers and mountain bikers, the authors suggest this may be due to cumulative disturbance factors (e.g., speed, noise from conversation vs. noise from vehicles on trails, interpretations of human forms on foot vs. bike) evening out rather than the modes having precisely the same sets of impacts. Likewise, while the study found concrete differences between species in their alert distances, flight distances, and distances moved, it is difficult to conclusively explain those differences or to extrapolate to other species and contexts. Perhaps the bison studied travelled shorter distances in flight because annual roundups conditioned them to human presence or because their size gives them more confidence; it would be overly simplistic to assume that for all species, safe approach distances scale inversely with size.

Other studies have documented different behaviors in other species. Papouchis et al. (2001) studied the responses of Desert Bighorn Sheep (*Ovis canadensis nelsoni*) to human recreation at Canyonlands National Park in Utah. While the researchers found the sheep to react "severely" to hikers (fleeing in 61 percent of encounters), vehicles (17 percent), and mountain bikers (6 percent), they noted individual

[6] Clinchy, et al., 2016
[7] Patten, Burger, & Mitrovich, 2019
[8] Taylor & Knight, 2003
[9] Taylor, AR and Knight, RL, 2003, "Wildlife Responses to Recreation and Associated Visitor Perceptions." Ecological Applications, 13: 951-963. https://doi.org/10.1890/1051-0761(2003)13[951:WRTRAA]2.0.CO;2

variations as some sheep living nearer to high-traffic roads appeared habituated to humans and others avoided the area. Papouchis et al. go on to say:

> *Overall, there was an avoidance of the road corridor by most other bighorn sheep in the high-use area where all animals, on average, were found 39% farther from roads (490 ±19m vs. 354 ±36m) than in the low-use area. This avoidance of the road corridor by some animals represented 15% less use of potential suitable habitat in the high-use area over the low-use area. Increased sensitivity to hikers in the high-use area was suggested by a greater responsiveness by males in autumn and greater distance fled by females in spring. Responses of bighorn sheep were greater when human activity approached at the same elevation, when sheep were moving or standing, when female interactions occurred in spring and summer and male interactions occurred in autumn, and when sheep were farther from escape terrain. We recommend managers confine hikers to designated trails during spring lambing and the autumn rut in desert bighorn sheep habitat.*

This study highlights how wildlife behavior can vary in different seasons, between sexes within species, and between individuals even of the same species. At refuges where conservationists consider multiple target species, it may be difficult to design solutions that are effective in all conditions.

In coastal areas, studies have found that beachgoers engaged in more active behaviors (e.g., bicycling, jogging, or walking) are more likely to flush birds than those involved in more passive activities (e.g., sunbathing, fishing).[10] One study concluded that human activity, which causes an individual or group of shorebirds to alter their normal behavior, can lead to an additional energy expenditure by the birds.[11] This activity can disrupt or prevent shorebirds from effectively using important habitats and from conducting the activities of their annual cycle that would occur in the absence of humans. Relatedly, another concern is the threat of beachfront habitat loss caused by activities such as bicycling, which can alter shorebird behavior by disrupting foraging patterns resulting in reduced health and wellbeing.[12] Productivity and survival rates may also be reduced. Habitat loss caused by bicycling and other recreational activities can even cause shorebirds to abandon the habitat completely. A recent study in San Diego, CA, found that wildlife positively responded to temporal closures of trails to hikers and cyclists, suggesting strategies to limit recreational use during breeding or other sensitive periods are effective (Larson C. S., 2020).

In a review of global literature, researchers found the most evidence of negative effects on reptiles, amphibians, invertebrates, and nesting birds of prey. The study found the most evidence of more positive effects on birds, particularly corvids, and mammals, particularly rodents (Larson, Reed, Merenlender, & Crooks, 2016). It is important to understand the level of impact to each species; for example, waterbirds were found to distinguish between walkers and bikers, with the impact on the species being relative to the extent of access and proximity to nesting habitat (McLeod, 2013). It is also critical not to assume that an animal is tolerant of recreation simply because it does not exhibit a visible response (Mitrovich, 2020).

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[10] Burger 1981, 1986; Lafferty 2001; Mayo et al. 2015; Althouse 2016

[11] Mengak et al. (2019)

[12] Iglecia, 2021

Management Implications (Marion & Wimpey)

- When building new trails, avoid riparian or wetland areas.
- For existing trails, consider discouraging or restricting access during sensitive times/seasons (e.g., mating or birthing season) to protect wildlife from undue stress.
- Wildlife impacts are greatly minimized when visitors stay on trails as wildlife have a well-documented capacity to habituate to non-threatening recreational uses that occur in consistent places.
- Educate trail users in 'leave no trace' practices and teach appropriate behaviors in areas where wildlife is found.

Impact of Bicycling on Vegetation and Soil

Vegetation

On formal bicycle trails, most vegetation is typically removed by trail construction, maintenance, and visitor use. Bicycling along the edges of the trail or off trail cause vegetation to be trampled. This is the primary avoidable impact to vegetation and consists of damage to plant leaves, stems, and roots; reduction in vegetation height; change in the composition of species; and loss of plants and vegetative cover. Complete loss of vegetation cover occurs more quickly in shady forested areas and less quickly in open areas with resistant grassy vegetation. Once trampling occurs, vegetation is slow to recover; however, studies have consistently shown that the most impact occurs with initial or low use with a diminishing increase in impact associated with increasing levels of traffic. Excessive opening of the over story allows greater sunlight penetration that permits greater vegetation compositional change and colonization by non-native plants (Larson, Reed, Merenlender, & Crooks, 2016).

The introduction of invasive species, inadvertently transported by visitors or on bicycles, is another concern. The ecological impacts are not fully understood, but once a few non-native species are introduced to a trail corridor, they are often able to outcompete native plants and spread away from the trail corridor in undisturbed habitats (Marion & Wimpey).

Management Implications (Marion & Wimpey)

- Design trails that provide the experience that bicyclists seek to reduce their desire to venture off trail.
- Locate trails away from rare plants and animals and from sensitive or critical habitats of other species.
- Keep trails narrow to reduce the total area of intensive tread disturbance, to slow trail users, and to minimize vegetation and soil impacts.
- Locate trails on side-hills where possible to reduce widening and off-trail trampling.
- Seek to avoid day-lighting the trail corridor.

Soil

Four common forms of soil degradation on bicycle trails include soil compaction, displacement, erosion, and muddiness. Soil compaction is caused by the weight of the rider and their bicycle. This impact is desirable on the trail itself, as compacted soil resists erosion and displacement. It is also an expected outcome of a primary resource protection goal to limit trailside impacts, as concentrating traffic on a narrow tread necessarily results in higher levels of soil compaction.

Soil displacement occurs when riders push soil laterally, causing the development of ruts, elevating inslopes, berms, and compounding drainage problems. Soil displacement typically occurs where soils are damp or loose and when riders are moving at higher rates of speed, turning, or braking.

Soil erosion often occurs by wind or water and is largely avoidable with good trail design and maintenance. Properly designed drainage features will divert water from the trail, where vegetation and organic litter can filter out sediments.

Soil muddiness occurs both where there are areas of poor drainage and where soil compaction, displacement, or erosion has caused cupped treads where water pools. Riders tend to avoid these problem areas, thereby compacting soils along the edges and widening mud holes, among other adverse impacts (Marion & Wimpey).

Management Implications (Marion & Wimpey)

- When possible, build bicycle trails in dry, cohesive soils that easily compact and contain a larger percentage of coarse material or rocks.
- Minimize tread muddiness by avoiding flat terrain, wet soils, and drainage-bottom locations.
- Discourage or prohibit use of trails that are prone to muddiness during rainy seasons or snowmelt.

Bicycle Trail Maintenance and Cost Considerations

In the past, trail maintenance costs have largely gone untracked at any aggregate level (i.e., state, national) and it was generally perceived that trail maintenance costs were expensive. To fill this knowledge gap for a sub-set of trail systems, the Rails to Trails Conservancy conducted a comprehensive survey of trail maintenance costs on multi-use trails.[13] Ninety-five trail management organizations provided maintenance budget information on which the study was based.

Results of this study show that maintenance costs are not as high as many perceived them to be. When taking into account for volunteers, this study found that annual maintenance costs per mile in 2013–2014 averaged $1,006 for a crushed stone trail and $1,971 for a paved asphalt trail (note: the purchasing power of $1 in 2013 is approximately $1.15 today). Maintenance tasks included in these figures are mowing, vegetation management, tree clearing, surface repair and clearing, drainage, trailhead

[13] Rails to Trails Conservancy. Maintenance Practices and Costs of Rail Trails, https://www.railstotrails.org/resourcehandler.ashx?id=6336

amenities, sanitation, signage, access control, and trail features. Survey respondents depend heavily on volunteers, completing 58 percent of maintenance tasks. These figures do not include any extensive or exceptional repairs and are assumed to include only the most basic maintenance tasks needed to keep the trail usable.

Unpaved Trails

The cost of maintenance for unpaved trails varied widely across survey respondents and varied widely from year to year. Water erosion was reported as the most common form of damage to unpaved trails, followed by vegetation. This can be caused by grass growing through unpaved trail surfaces, vegetation encroaching on trail edges, or the proliferation of invasive species. Controlling damage caused by vegetation encroachment is manageable with a program of regular, scheduled inspection and preventative maintenance. Re-grading of unpaved trails is another common maintenance task. Based on survey respondents, the average time required for re-grading is two hours per trail mile.

Management Implications (Marion & Wimpey)

- Actively maintain the trail to provide a stable, predictable tread.
- Define the trail borders with logs, rocks, or other objects that will not impede drainage.
- Educate visitors to use low-impact riding practices, discourage off-trail travel, and increase awareness of the risk of carrying non-native plant seeds on bikes and clothing.
- Develop a safety management and maintenance plan with a schedule of tasks and inspections of related structures and facilities.
- Consider partnership with a volunteer organization to support basic maintenance tasks.

Case Studies

The following section presents six case studies of FWS stations and their unique circumstances regarding bicycle use on refuge lands. These circumstances range from refuges that provide designated bicycle routes to other refuges that determine it is in the best interest of visitor safety, habitat integrity, or both to prohibit any bicycling access within refuge property. Regardless of what regulations each individual refuge upholds, each station must consider several factors when making decisions regarding bicycle access such as, but not limited to, visitor safety, interactions with local species, and maintenance (Table 2).

Table 2: Refuge Bicycle Access Quick Reference Guide

Refuge	Context of Bicycle Access Regulations
Valle de Oro NWR, NM	Current bicycling access throughout the refuge. Impending phase-out of bicycling access on internal trails in consideration of the safety of visitors engaging in birding and walking. Perimeter trail to remain bike accessible.
Rocky Mountain Arsenal NWR, CO	Bicycle access on designated trails only. No bicycles allowed on the auto tour route in consideration of visitor safety in vicinity of local bison, as well as the protection of bald eagle nesting grounds.
San Diego Bay NWR, CA	Bicycle access prohibited to prevent soil erosion and affiliated habitat loss.
Chincoteague NWR, VA	Bicycle access on designated trails only. No bicycles allowed on beachfront area in prevention of habitat loss and disruption of local shorebird species.
Detroit River IWR, MI	Bicycle access prohibited in prevention of soil erosion and in consideration of visitor safety on narrow, marshy trails.
Shiawassee NWR, MI	Bicycle access on designated trails only. No bicycles allowed on the auto tour route in consideration of visitor safety and prevention of collisions. Maintenance of bicycle accessible trails pose fiscal and personnel constraints due to natural obstacles such as fallen trees, flooding, and invasive plant species.

Each FWS refuge makes an independent decision to implement or prohibit bicycle access within its boundaries. Any recreational activity permitted on refuge land must undergo a compatibility determination conducted by the refuge manager.[14] It is up to the refuge manager's discretion to determine the appropriateness of bicycle use on a refuge.

The refuge staff that participated in the preparation of case studies for this report acknowledged that, while evidence-based decisions based on locally derived data may be ideal to determine the appropriateness of bicycle use on refuges, it is not always available. In reality, refuge staff must rely upon existing literature pertaining to regions or habitats different than that of the refuge, or their own professional, yet anecdotal, experience when forming conclusions on regulations regarding permitting bicycle use on refuge property. One refuge referred to this responsibility as exercising Best Professional Judgement (BPJ), defined in their words as the highest quality technical opinion forming the basis of a decision after consideration of all reasonably available and pertinent data.

For many refuges, implementing regulations regarding bicycle access presents a challenge of balancing the conservation of natural resources while also considering public use and recreation. To provide a

[14] https://www.fws.gov/policy/603fw1.pdf

broad scope of this reality that many refuges face, several factors were considered to select a diverse representation of stations for case studies. These factors include a refuge's proximity and connection to urban bicycling trail networks, known regulations of either promoting or prohibiting bicycle access, and the types of wildlife and habitats conserved within refuge boundaries. Each case study presents current or pending regulations regarding bicycle access at refuges and the unique circumstances that influenced these decisions.

Valle de Oro NWR, NM

Adapting bicycling infrastructure in a changing refuge landscape

Valle de Oro NWR has been in a state of flux since its inception in 2012. Located adjacent to the riparian forest (bosque) on the east bank of the Rio Grande, the refuge is undergoing extensive conservation efforts to convert former dairy and alfalfa farmland into a mosaic of Middle Rio Grande Valley habitats with a particular focus on constructing wetlands within the refuge boundaries. As a designated urban refuge in close proximity to the Albuquerque metro area, the refuge welcomes cyclists and is accessible via regional bicycle routes. As the refuge continues to develop while undergoing conservation efforts, the station has a plan to adapt and modify bicycle infrastructure to meet both visitor and local environmental needs.

As of July 2020, the station has excluded motor vehicles on roads within the refuge beyond the Welcome Center, limiting access to pedestrians, equestrians, and bicyclists only. The station asks visitors arriving to the refuge by car to park at the Welcome Center, which maintains a lot capacity of approximately 30 vehicles. Many visitors to the refuge are from the surrounding residential area comprised mainly of single-family housing.

The refuge has worked with local partners to utilize the Federal Lands Access Program (FLAP) funding in efforts to improve bike routes to the refuge. The 2nd Street corridor, established in 2018, begins at Rio Bravo Boulevard (NM 500) at a connection with the Rio Bravo bike path and continues southward to the site of the future entrance to the Visitor Center. The corridor includes a reengineered bike path, paved sidewalks, landscaping, traffic control structures with connection to a local bus stop, and a regional commuter rail stop. A separate initiative currently in the development phase will serve as a continuation of the Paseo del Bosque Bike Trail and will provide a bicycle accessible route to the western entrance of the refuge. The Paseo del Bosque Bike Trail is a 16-mile route running north-south along the Rio Grande through the city of Albuquerque, starting at the Alameda Open Space and ending at Rio Bravo Boulevard. To extend the trail to the refuge, the station is utilizing FLAP funding in partnership with the Albuquerque Metropolitan Arroyo Flood Control Authority and Bernalillo County to erect a pedestrian bridge that will allow for bicycling traffic to continue along the Bosque trail over a storm water diversion channel.

At present, trails within the refuge are linear and open to bicycle access. As wetland restoration efforts are completed, current bicycling routes within the refuge will be phased out and new curvilinear trails will be situated around restored wetland habitats. Upon completion of this transition, the refuge plans to implement a new regulation restricting bicycle access along interior trails and establish a bicycle-accessible trail around the refuge perimeter, which will serve as the only bicycle accessible trail within refuge boundaries (Figure 2). For all other areas of the refuge, visitors will be requested to park their bicycles and navigate the refuge by foot. At present, there are no bicycle racks for parking located at the Welcome Center, however the new Visitor Center, slated to be completed in summer 2021, will include bicycle parking infrastructure.

The factors that influenced this decision to limit bicycling-accessible trails within the refuge relate more to visitor use patterns, particularly the act of birding, more so than a concern over any adverse effects on local wildlife. Whereas the station does maintain on-site bird surveys in all seasons throughout the year, the intention is to record all species seen. The surveys focus on the relationship of birds with humans and built infrastructure, such as a concern for migrating geese and cranes in close proximity to the nearby airport and air force base. The findings of bird surveys have not directly influenced the

station's decision to limit bicycles on interior trails; rather, the implementation of new policies is in consideration of visitors, particularly birders and wildlife viewers, who have expressed concerns over collisions with cyclists when not looking. The refuge also received requests to maintain trails limited exclusively to walking. Refuge staff have expressed that the primary mission of the station is to connect the public with the outdoors, and not the conservation of any particular type of wildlife.

Valle de Oro is a unique refuge as it has had the opportunity to plan bicycling accessibility as a component of its rehabilitation efforts in converting refuge lands from former farmland into protected natural habitat. Refuge staff have shared that along with community outreach and environmental estimates, the implementation of bicycling infrastructure has been an important element of development plans since the founding of the refuge.

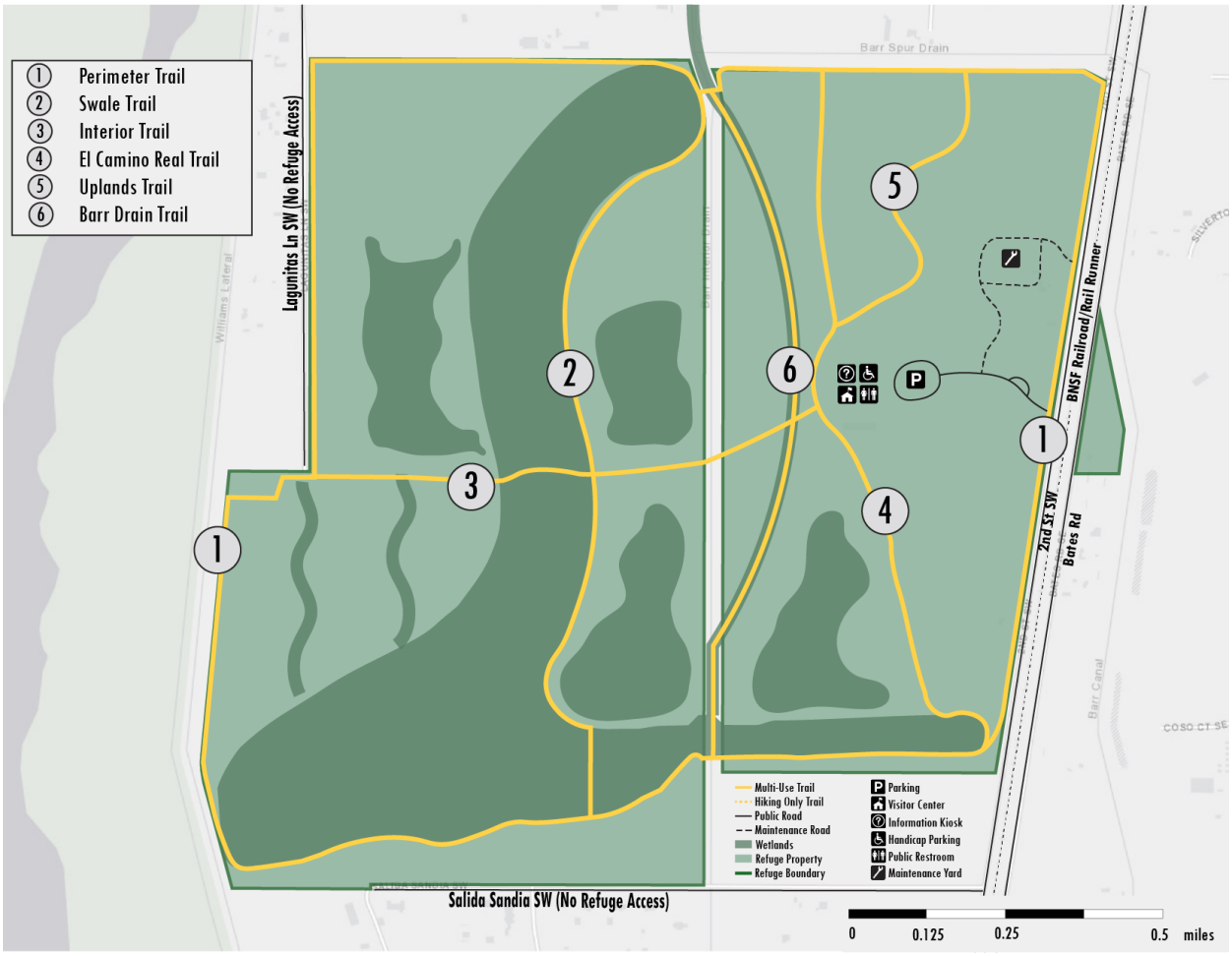

Figure 2. A rendering of future trails throughout Valle de Oro NWR upon completion of restored wetland areas. The exterior trail will be accessible to bikes, while interior trails will prohibit bicycling use. Credit: Valle de Oro NWR

Rocky Mountain Arsenal NWR, CO

Creative approaches to expand bicycle accessibility

An auto tour route in close proximity to roaming bison was one factor of many that for years rendered bicycles to be prohibited throughout Rocky Mountain Arsenal NWR. However, refuge staff committed to the goal of expanding refuge accessibility have found creative ways to implement safe hiking and biking trails for visitors seeking new ways to explore the conserved lands.

Considered one of the largest refuges designated as an urban refuge in the US, Rocky Mountain Arsenal NWR is a 15,000-acre expanse of prairie, wetland, and woodland habitat northeast of Denver. The refuge, which is home to roaming bison, is also a sanctuary for more than 330 species of animals, including bald eagles, deer, and black footed ferrets, one of the most endangered mammal species in the country.

Until recently, the refuge has not allowed bicycling within its boundaries. However, community involvement in the 2010s paved the way for trail expansion and modified policies to allow for bicycle access, including e-bikes, on select trails throughout the refuge. The goals of the refuge have been to increase opportunities for visitors to access the refuge and explore by alternative modes, including bicycles, while strategizing where bike-permissible areas are located to ensure the safety of both visitors and resident wildlife.

To make the refuge accessible to bikes while maintaining the integrity of the conserved lands, identifying designated bike route locations involved strategic planning. A majority of trails open to bicycling are located south of 64th Avenue, an existing road through the refuge that serves as a physical dividing line from open prairies where bicycling and hiking access are prohibited (Figure 3). The prairie lands north of 64th Avenue include the auto tour route to view bison as well as protected bald eagle nesting grounds. The refuge devised the strategy to keep off-road bike paths south of this road with the intention to decrease confusion and simplify signage throughout the refuge.

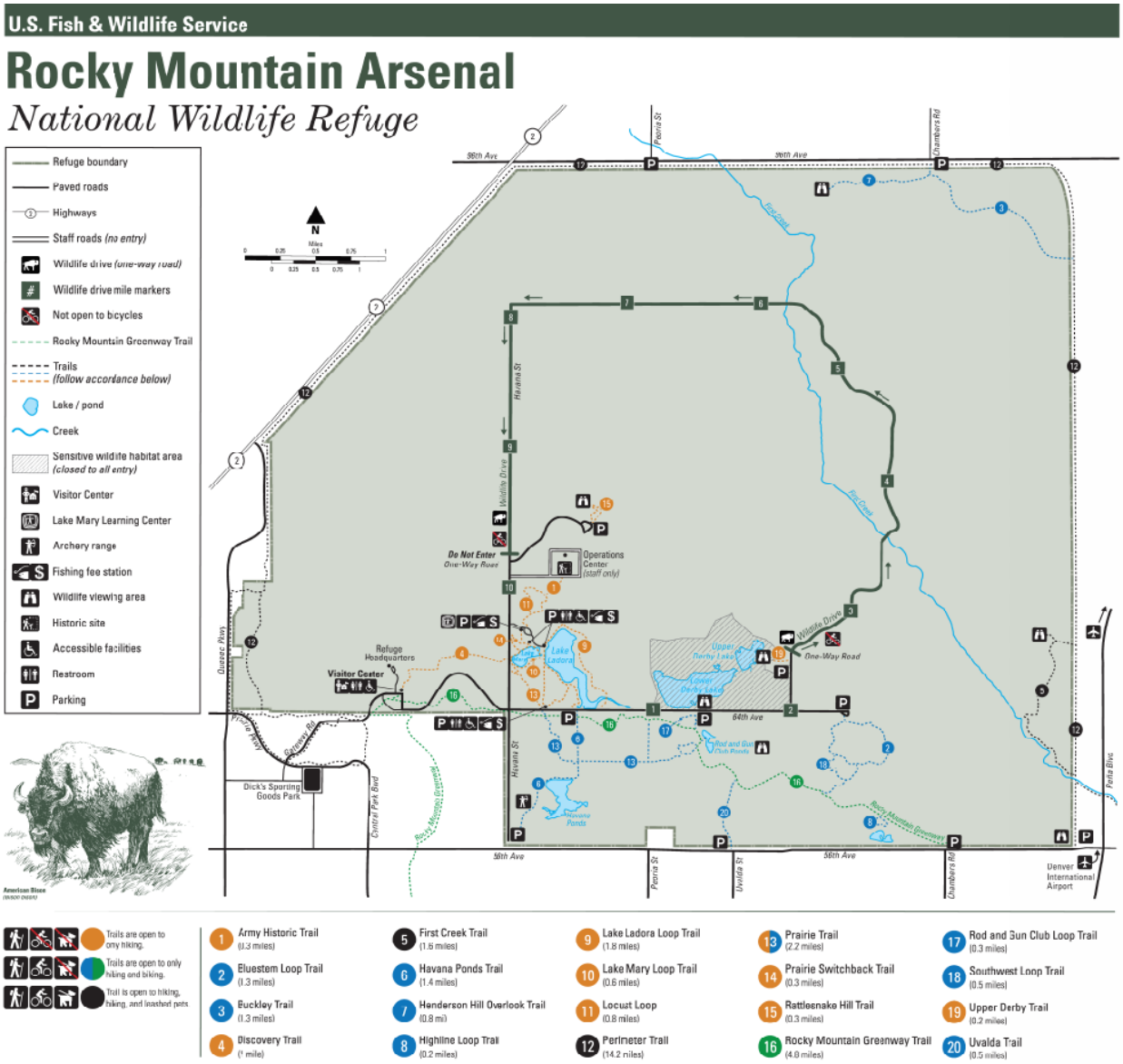

Figure 3. Trails throughout Rocky Mountain Arsenal NWR are color coded to inform visitors of their intended use. Trails within the refuge boundaries accessible to bicycles are color coded blue and green and are notably located south of 64th Avenue. Trails around the perimeter, designated by a dotted black line, are also open to bicycle access.[15] Credit: Rocky Mountain NWR

At present, the station has not conducted any study directly assessing the impact of bicycles near wildlife throughout the refuge. Nonetheless, the station bases its regulation decisions on preventative measures to provide both a safe and enjoyable experience for visitors at a distance from any conflict with bison and to reduce the disturbance of sensitive ecological locations such as bald eagle nesting grounds also located north of 64th Avenue.

[15] Higher resolution map of Rocky Mountain Arsenal NWR found here: https://www.fws.gov/uploadedFiles/RMANWR%20Trail%20Map%2030x32%20georef.pdf#a

On the refuge, signage indicating a series of color-coded trails has been implemented designating sites where bicycle access is allowed. E-bikes have also been allowed on refuge grounds with select classes of e-bikes permitted on designated color-coded trails. Class 1 e-bikes (those equipped with a motor that provides assistance only when the rider is pedaling, and that ceases to provide assistance when the bicycle reaches the speed of 20 miles per hour) are allowed on blue and green trails located south of 64th Avenue. Other types of e-bikes, such as class 2 and 3 e-bikes, are only allowed on the perimeter trail and designated refuge roads outside of the auto-tour route. The justification for these decisions involved allowing a wider variety of transportation options for visitors to explore the refuge, particularly modes such as bicycling and e-bikes. The station sees bicycling along designated paths an option that may improve accessibility along long roads otherwise prohibitive to walking.

Rocky Mountain Arsenal NWR has put forth novel approaches to increase bike access within the refuge and has become a partner in expanding regional bicycling infrastructure. Following a Master Plan finalized in 2015, *The Comprehensive Conservation Plan for the Rocky Mountain Arsenal National Wildlife Refuge*,[16] the refuge collaborated with a series of local partners to secure FLAP funding in 2016 to connect the refuge with other regional outdoor destinations including Rocky Flats NWR and Rocky Mountain National Park along the Rocky Mountain Greenway.[17] The station has also utilized FLAP funding in efforts to increase multimodal access for visitors, particularly local residents who live in historically underserved communities. These initiatives include a trailhead at 96th Avenue and Chambers Road with pedestrian access to the Perimeter Trail, two trailheads along 56th Avenue at both Chambers and Ulvada Streets with pedestrian access to the southern portion of the refuge, as well as a paved parking lot within the refuge on the south side of Lake Ladora. These initiatives underscore the objectives of refuge staff who see increased multi-modal access, including bicycling, as not only a means to improve accessibility to the refuge, but as a way to provide alternative modes to enjoy its wildlife and nature as well.

[16] https://www.fws.gov/mountain-prairie/refuges/co_rkm.php

[17] Rocky Mountain Greenway: https://www.fws.gov/nwrs/threecolumn.aspx?id=2147589172

San Diego Bay NWR, CA

Coexisting with popular bike routes in an urban environment

Promoting bicycle infrastructure, especially in urban environments, is often viewed as a boon for improved accessibility and an outlet for improved physical health. In the scope of land conservation, however, bicycling can also correspond with unintended negative consequences. San Diego Bay NWR, a part of the San Diego National Wildlife Refuge Complex (NWRC), has navigated these challenges by devising strategies to coexist in an urban environment where sensitive protected lands directly border a highly trafficked regional bicycle thoroughfare.

San Diego NWRC is a series of wildlife refuges located in San Diego County and Orange County and comprises San Diego NWR, San Diego Bay NWR, Tijuana Slough NWR, and Seal Beach NWR. The refuges within this complex preserve various habitats including, but not limited to, saltwater marsh, freshwater marsh, intertidal salt marsh, and inland coastal sage scrub woodlands. The refuge lands of the NWRC are remainders of habitat that was once much more extensive, physically connected, resilient, and biologically diverse, emphasizing the challenge for refuges within the complex to fulfill their mission to preserve that which remains. In particular, San Diego Bay NWR staff acknowledge the inherent compromise in providing the public recreational access throughout these habitats and the challenge to maintain conservation efforts. Bicycling, a popular recreational activity in the metro area, presents itself as a particular concern for refuge staff, resulting in San Diego Bay NWR opting to prohibit bicycling access within refuge boundaries.

The decision of San Diego Bay NWR to prohibit bicycling access is directly linked to the characteristics of the habitats it serves to protect. The station is an urban refuge conserving remaining upland coastal salt marsh and mudflat habitats on the banks of San Diego Bay. The refuge is comprised of two primary units, the Sweetwater Marsh and South San Diego Bay (SSDB). The Sweetwater Marsh Unit notably provides nesting habitat for several species of ground nesting birds in its intertidal mudflat and coastal salt marsh habitats. The SSDB Unit flanks the southern extremity of San Diego Bay, with fragile salt ponds that provide necessary resting and foraging habitats for a variety of resident and migratory seabirds. Whereas the station has not conducted its own study on the impacts of bicycling on local wildlife, refuge staff base their decision to restrict bicycle access on a review of existing literature on the impacts of recreational activity—such as bicycling, but also hiking and dog walking—and the effect on soil erosion, habitat degradation, and wildlife disturbance. With this knowledge, the refuge staff determined with Best Professional Judgement (BPJ) that bicycles traversing on publicly accessible roads and trails within refuge boundaries would result in unacceptable levels of disturbance to foraging birds and other resident wildlife.

A comparison with conditions at San Diego NWR, within the same refuge complex, provides a clearer perspective of the types of disturbances that concern refuge staff. San Diego NWR, located east of San Diego, inland in the city of Jamul, preserves habitats ranging from coastal sage scrub and oak woodlands to freshwater marsh. The station also provides bike accessible trails throughout its boundaries. In the Environmental Assessment (EA) of the 2014 Comprehensive Conservation Plan (CCP), [18] the refuge cites that trail use and unauthorized trail construction (for both hiking and mountain biking) have resulted in substantial changes to the natural landscape of the station, including the removal of native vegetation. Some of the direct impacts on native vegetation include incidental destruction of vegetation caused by

[18] https://www.fws.gov/refuge/San_Diego/what_we_do/planning.html

foot or bicycle traffic, compaction of soil, and an introduction of weeds and invasive species, which can thrive in degraded soils stripped of native vegetation.

The sensitive link between habitat loss and the health and wellbeing of dependent wildlife has prompted staff at San Diego Bay NWR to err on the side of caution when considering access for recreational activities, including bicycling. Refuge staff note that many of the species the station strives to conserve are cryptic or rely on specific biogeochemical conditions in soils that are easily destroyed by trampling or erosion caused by wheels. An example of this is the cryptogamic soil crusts associated with the host plant for the endangered Quino checkerspot butterfly. Such crusts are extremely fragile and important to ecosystem functionality at a very basic level and are slow to re-establish once removed by trampling or erosion.

Despite the policies at San Diego Bay NWR to restrict bicycle access, the urban refuge still must contend with the effects of bicycling each day as segments of its units are bordered by the Bayshore Bikeway, a 24-mile bike route that nearly encircles the San Diego Bay urban area. Seven miles of the Bayshore Bikeway contour the southern border of the SSDB unit, which has prompted the refuge to take proactive measures to protect the adjacent refuge habitats while accommodating riders along the bikeway. Whereas the Bayshore Bikeway is not located within FWS boundaries, the bikeway bordering the seven miles of the SSDB unit created an area with conflicting usage. Visitors to the refuge, particularly birdwatchers, would stop along the bike path to view the refuge's salt marshes. The volume of stopped bikes along the highly trafficked route presented a safety hazard, while also leading some visitors and cyclists to veer off the bike paths and tread on sensitive salt marsh habitat, causing degradation.

The refuge responded by erecting the Bayside Birding and Walking Trail, a $600,000 project funded primarily through grants provided by the California State Coastal Conservancy. Completed in 2016, the trail is a 0.4 mile walking route and a connected wildlife observation deck on refuge property (Figure 4). No bikes are allowed along the trail, and visitors arriving by bike are requested to park at designated parking areas along the Bayshore Bikeway, three of which are in close proximity to the refuge trail. The trail provides a safer path for visitors to view the environment adjacent to the Bayshore Bikeway while preventing further erosion to the sensitive marsh areas. Interpretive signs have also been incorporated along the trail increasing educational awareness of the area.

Figure 4: One of three viewing platforms along the Bayside Birding and Walking Trail, a bike-free zone for visitors along the southern boundary of San Diego Bay NWR. Photo Credit: San Diego Bay NWR

The unique situation of San Diego Bay NWR staff working to protect sensitive habitat areas while also providing compatible recreational activities along a highly trafficked bike path required both flexibility and creativity to strike the right balance of addressing the needs of the environment and visitor safety.

The Bayside Birding and Walking Trail represents a creative solution that provides benefit to both visitors to the refuge as well as the area's natural habitat. By incorporating new resources along the Bayshore Bikeway, such as the Bayside Birding and Walking Trail, San Diego Bay NWR successfully found a balance so that bicycling infrastructure can coexist next to refuge protected lands, while also creating an inviting trail for visitors to learn more about the local environment.

Chincoteague NWR, VA

Maintaining a bicycle-friendly atmosphere in a popular family vacation destination

At Chincoteague NWR, public visitation has remained consistent over the past 20 years with approximately 1.25 million visits annually. For this reason, the refuge maintains a mission to raise public awareness and appreciation of the refuge and to generate revenue that supports public and wildlife services. Such high visitation provides a need for the refuge to implement management strategies and direction to minimize human disruption to the natural environment, which also include the refuge's decisions regarding bicycle-accessible areas.

Chincoteague NWR offers many recreational options for visitors, including cyclists. The refuge shares a special connection with Chincoteague Island, which all visitors must pass through to arrive on Assateague Island where the refuge is located. Chincoteague Island is considered a gateway community to the refuge and serves as a popular holiday destination for families. The average stay of visitors to Chincoteague Island is three to four days, and the refuge is often a focal point of outdoor activities during these visits. Bicycles are available for rent on the island, and the Beach Access Road, referred to as Maddox Boulevard on Chincoteague Island, includes a bike route comprised of both dedicated bike lanes and shared-use roads in different locations. The bike route continues from the town onto Assateague Island and through the refuge to the public beach.

As one of the most popular refuges in the country, the refuge maintains a unique regulation limiting vehicle access in select areas during designated parts of the day. Vehicles may enter the refuge from 6am until closing; however, from opening until 3pm, vehicles are prohibited from entering the refuge's Wildlife Loop Trail. This regulation is well received by visitors who enjoy non-motorized access to the Wildlife Loop Trail, which remains open to hikers and bikers. The refuge also maintains a $10 fee per vehicle upon entering the refuge, while there is no fee for visitors arriving to the island by bicycle. This further encourages the use of bicycles to access and explore the refuge. Chincoteague staff believe that by encouraging bicycling usage, the refuge can reduce the demand, and thus the impact, of motor vehicles parked at the recreational beach.

Spanning over 14,000 acres, Chincoteague NWR is a sprawling refuge located on Assateague Island along Virginia's coast. Most visitor use is concentrated in areas near the vicinity of the refuge entrance that include paved roads, particularly the Wildlife Loop Trail and routes to the beachfront, as well as paved and unpaved multi-use trails, some of which are accessible by bicycle (Figure 5). Each trailhead is equipped with a bike rack, and the refuge has portable bike racks to place throughout the refuge as needed. Access routes are strategically located to retain visitor traffic in designated areas and conserve critical habitats at the southern and northern extremities of the island. No bikes are allowed along the beachfront areas, and signage is placed throughout the refuge designating zones where bicycle access is not permitted.

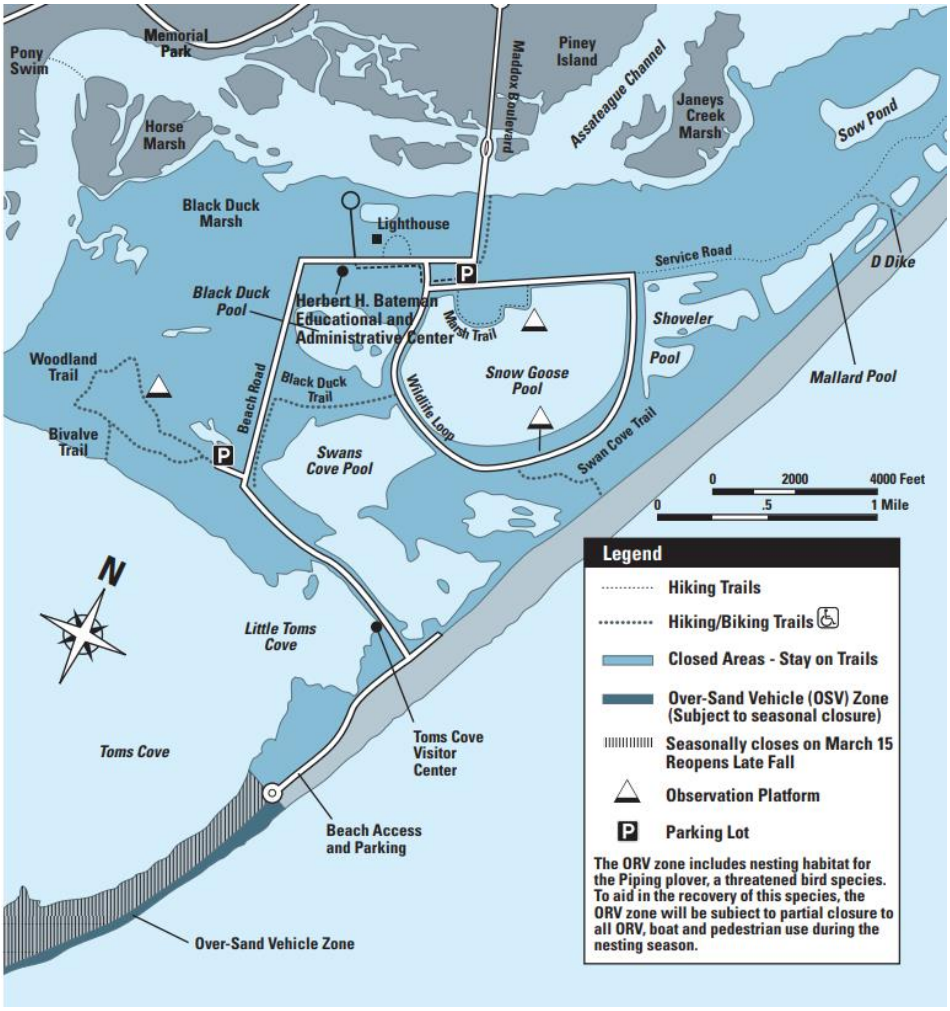

Figure 5. This map demonstrates the close connection of Chincoteague NWR with Chincoteague Island (shown as dark gray to the north). All paved roads accessible to public vehicles are also open to cyclists, and select trails are open to bicycles. The light gray areas in the south denoting the Beach Area are prohibited to bicycles.[19] Credit: Chincoteague NWR

The decision of the refuge to prohibit bicycle access in select areas, such as the beachfront, addresses concerns of habitat degradation related to human-caused disturbances including bicycling. Whereas the refuge has not conducted its own study of the effects of bicycling on local habitats, the refuge cites existing literature (summarized previously) on the effects of recreational activity on habitat degradation and wildlife disturbance in coastal areas as a basis for their decision where to prohibit bicycle accessibility.

In addition to restricted bicycle access along beaches, the refuge takes further measures to protect select species during sensitive breeding periods, such as the piping plover, when beach access to all visitors is limited annually beginning March 15th through September. The refuge also references existing

[19] Higher resolution map of Chincoteague NWR found here: https://www.fws.gov/uploadedFiles/RECOLOR%20Chincoteague%20Map%20tear%20Sheet%202020%20FINAL%20FINAL.pdf

literature as the basis for implementing this regulation. The potential of harm to shorebirds, such as the piping plover during a vital, yet sensitive breeding period, has influenced the refuge to limit beach access in efforts to protect the species.

The refuge also takes measures to regulate visitor interaction with Chincoteague ponies, one of the most iconic species on the island. The ponies are located in fenced off areas to prevent close interaction with visitors, as well as further north on the island where there are no official visitor routes. The rationale for designating limited access for all visitors, including cyclists, in areas where ponies inhabit is for the safety of visitors and the ponies alike. Refuge staff note anecdotally that horses bite and kick in response to crowding or competition for food, which can be a risk for visitors, especially children, if approaching too close. In terms of the effects on the ponies, refuge staff point out that horses can become unafraid of humans (which is notably not the same as "being tame") and may venture closer to roads, which increases the risk both to visitors and the propensity of injury or death of horses by vehicles. An example of how such risks influence decisions regarding the location of bicycle-accessible routes can be found in the 2015 Comprehensive Conservation Plan for Chincoteague and Wallops Island National Wildlife Refuges.[20] The document outlines a plan to expand recreational beach access 1.5 miles north; however, the refuge has stalled this initiative as some staff have expressed concern about the higher number of visitors that would be more inclined to disperse north in search of ponies if bicycling were permitted on the beachfront or the northern reaches of the Service Road.

Current refuge regulation also maintains that e-bikes are permitted in any areas where bicycle access is allowed. As mentioned earlier, this regulation is in accordance with a regulation delivered by FWS to the Federal Register, and made effective on December 2, 2020, permitting the "use of e-bikes on any refuge roads and trails where traditional bicycle use is allowed, provided it is consistent with a refuge's statutory purpose and the refuge manager determines it to be a compatible use."[21] Whereas e-bikes can serve to increase recreational opportunities on public lands, refuge staff do express safety concerns, particularly related to speeding.

Collaboration has been a focal point of the refuge's efforts to establish bike-friendly access to and throughout the refuge. In 2017, Chincoteague NWR transferred $1.5 million in funds from the *Federal Transit Administration Paul S. Sarbanes Transit in the Parks Program*[22] to the Town of Chincoteague to improve and promote bicyclist and pedestrian safety for visitors accessing the refuge from the town. The grant money assisted in facilitating goals mapped out in the Town of Chincoteague's 2010 Comprehensive Plan[23] and 2020 Transportation Plan.[24] This included traffic studies and project designs as well as the implementation of bicycle-accessible infrastructure. Some of these projects include the creation of a shared roadway for bicycles along Main Street and Ocean Boulevard, the creation of a bike path connector between Ocean and Maddox Boulevard at Coach's Lane, as well as crossing infrastructure, signage, and bike repair stations. Future initiatives are also underway to establish new bike routes and infrastructure to replace existing routes leading up to the beachfront on Assateague Island.

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[20] https://www.fws.gov/refuge/Chincoteague/what_we_do/CCP.html
[21] https://www.fws.gov/home/feature/2020/2020-2021-NWRS-Use-Of-Electric-Bicycles-Final-Rule.pdf
[22] https://www.transit.dot.gov/funding/grants/grant-programs/paul-s-sarbanes-transit-parks-program-5320
[23] https://www.chincoteague-va.gov/pdf/5-Year-Update-Approved.pdf
[24] http://www.virginiadot.org/projects/resources/Chincoteague_plansummary_FINAL.pdf

Detroit River IWR, MI

A regional supporter of bicycle-friendly infrastructure

Detroit River International Wildlife Refuge (IWR) is an urban refuge located 20 miles south of Detroit consisting of over 20 separate units along 48 miles of the Detroit River and western Lake Erie. In October 2020, the Refuge Gateway and Humbug Marsh Units in Trenton were opened for limited public visitation. That access was expanded to seven days a week beginning in April 2021. The Refuge Gateway Unit located adjacent to the Humbug Marsh Unit is unique in that it is not exclusively FWS property but rather cooperatively maintained under an intergovernmental agreement with Wayne County. Wayne County maintains ownership of 40 acres of the site while FWS owns four acres where the John D. Dingell Jr. Visitor Center is located. In addition to the Visitor Center, the Refuge Gateway area serves as not only a physical gateway to adjacent Detroit River IWR property but also a "gateway" to outdoor recreational activities, including a fishing pier, a handicap accessible kayak launch, and a natural playscape. The Gateway is equipped with bike racks as well as a bicycle repair station, encouraging visitors to travel to the refuge entrance by bike and explore on-refuge property by foot (Figure 6).

Figure 6: Bicycle parking and repair station infrastructure in front of the John D. Dingell Jr. Visitor Center, considered the gateway into the Detroit River IWR. Credit: Detroit River IWR

Bicycle access is prohibited throughout all areas of Detroit River IWR. No accessible bike paths currently exist, and due to the muddy constitution of the marshland environment throughout the riverfront refuge, no bike paths are intended to be developed. Refuge staff have already noticed that in the short period the refuge has been accessible to the public, foot traffic alone is already degrading the trail surface. Based on professional experience and knowledge, the refuge staff conclude that expanding trail use to include bicycles would only exacerbate this problem and would therefore not be sustainable. The current trail system is also short and narrow and refuge staff are of the opinion that keeping use limited to foot traffic is in the best interest of visitor safety to reduce any user conflict.

Whereas Detroit River IWR staff do not envision the conserved environment within refuge lands to be conducive to safe bicycling access, the refuge does see itself as a proponent of bicycling to access outdoor recreational activities throughout the region. The Refuge Gateway, being in part owned by Wayne County and thus outside of refuge boundaries, includes paved roads accessible to bicycles, connecting the refuge entrance to the Downriver Linked Greenway Initiative's 30-mile trail system (Figure 7).

Figure 7: A sign denoting a bike trail connecting the entrance of the Humbug Marsh Unit of Detroit River IWR with the Downriver Linked Greenway trail system. No bicycles are allowed within Detroit River IWR boundaries; however, the refuge still maintains bicycle infrastructure in front of key entrances. Credit: Detroit River IWR

The Gordie Howe International Bridge, currently under development, will connect Detroit to Windsor, Ontario, in Canada and will be approximately 14 miles away from the refuge. The bridge, slated to open in 2024, will include both cyclist and pedestrian access and is considered one of the impetuses for the interest in bike paths throughout the region. The Detroit Greenways Coalition has rendered extended bike routes that could connect the international metropolitan area, motivating local communities to direct greater focus to bicycling infrastructure in their transportation planning initiatives. Detroit River IWR is located along greenway paths connecting these cities and towns, thus positioning the refuge to serve as a partner and key player in advocating for expanded bicycle access throughout the region.

Detroit River IWR staff stress that refuge developments have been heavily interdependent on regional partnerships. The refuge sees themselves as serving an integral role in facilitating community involvement to promote wildlife conservation and outdoor recreation opportunities in the region. Some of these off-refuge initiatives include an embankment rehabilitation and kayak launch located at Ecorse Creek in Ecorse as well as a kayak concessionaire in Elizabeth Park in Trenton, both locations accessible along the Downriver Linked Greenways paths. Despite these parks not being FWS property, the collaborative efforts put forth between the refuge and regional partners will expand the possibility for visitors to explore the environment surrounding the refuges by bicycle, kayaks, and other modes. These efforts show that even when FWS stations may decide to prohibit bicycle access throughout refuge

lands in consideration of trail integrity and visitor safety, stations can still serve as positive catalysts for the benefits of bicycling accessibility within their communities.

Shiawassee NWR, MI

Fiscal and environmental constraints on bicycling infrastructure

Shiawassee NWR, located southwest of the metropolitan area of Saginaw, Michigan, encompasses over 10,000 acres of revitalized, forested habitat adjacent to flat farmland and several river tributaries. The Tittabawassee, Cass, Flint, and namesake Shiawassee River all flow around the refuge as part of a watershed leading to the Saginaw River draining into Lake Huron. Flooding occurs annually in the refuge as spring rains and snowmelt throughout Michigan raise rivers several feet. Whereas the refuge does offer options for visitors to explore refuge land, including select areas where bicycling is permitted, the challenges of maintaining the refuge due to its size and regular flooding are numerous, thus limiting the ability to provide reliable, sustainable bicycling infrastructure for visitors.

Officially, the refuge promotes two trails that are bicycle accessible. These include the Ferguson Bayou Trail located at the southwest area of the refuge property and the Woodland Trail, the entrance of which is located in the northwest. The two trails are self-contained and do not connect; the entrances to each trail are located at separate entrances to the refuge otherwise bifurcated by various river tributaries.

The Ferguson Bayou Trail, listed online as a family-friendly trail offering bicycle accessibility, is a 4.4-mile flat gravel loop throughout an area of floodplain forest south of the Shiawassee River (Figure 8). Located adjacent to a largely rural area in the southeast of the refuge, nearly all visitors arrive by car with their bikes on racks. The parking lot is also the entrance to the Wildlife Drive, which is the only auto tour route advertised at the refuge and fully surrounds the Ferguson Bayou Trail. As part of a longstanding regulation of the refuge to separate car and bicycle traffic in consideration of visitor safety, no bicycles are allowed on the 6.5 mile, one-way auto tour route. Despite these limitations, all but one observation platform accessible on the Wildlife Drive are also accessible via routes separated from vehicle traffic on the bike-accessible Ferguson Bayou Trail.

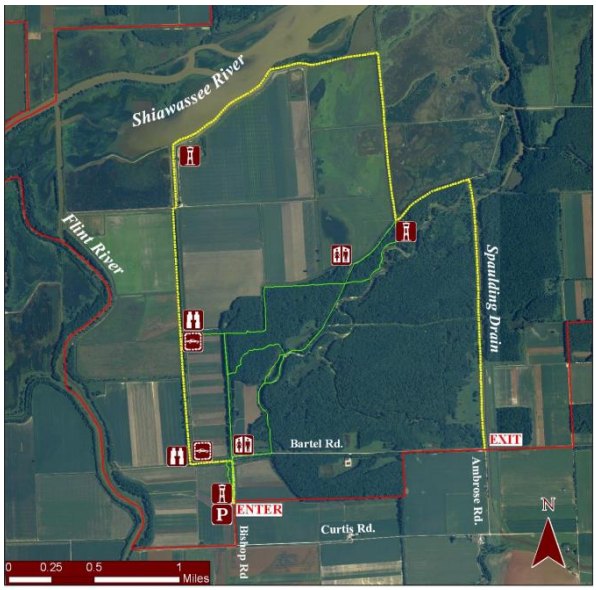

Figure 8: Image of Shiawassee NWR Wildlife Drive (yellow) and Ferguson Bayou Trail (green)

Refuge staff have observed that bird species in the area, particularly waterfowl, shorebirds, and wading birds, are particularly sensitive to close encounters with humans during migration seasons in the spring (March-May) and fall (September-November). Staff note that the location of trails and auto tour routes are positioned to reduce disruption of nesting and migrating bird species, but these decisions are based on all forms of human disturbance, including cars and hikers, and not exclusively bicycles. The refuge maintains data on waterbird populations throughout the refuge, and staff utilize this data to keep the best interests of local species and habitats in mind when making public use decisions (at present, the refuge has based no public use decisions on data related explicitly to bicycling use).

The 5-mile Woodland Trail (Figure 9), located between the Shiawassee and Tittabawassee Rivers, is accessible from the northwest of the refuge. The trailhead is comparatively more accessible to the Saginaw metro area and includes a connection to a bike trail along Stroebel Road maintained by Saginaw County Parks. According to refuge staff, the Woodland Trail, once regarded as a quality mountain biking trail by long-term local visitors, has faced environmental setbacks in recent years. Two portions of the trail, the River Loop and the Marsh Loop, are now defunct and closed off to visitors due to river flooding. In addition to annual flooding concerns, the forested area in this portion of the refuge contains several ash trees invaded by ash borers and are now dead. Fallen ash trees block several trails and require great amounts of station time and labor to remove and maintain the trails. In addition, Common Buckthorn, an invasive species to the region, has grown rampant in the area, growing thick and dense and encroaching along the trails. The refuge is in the progress of experimenting with efforts to combat this invasive species. This situation serves as an example of general refuge maintenance initiatives considering bicycling access, expansion, and maintenance efforts as secondary or tertiary concerns.

Figure 9. This map denotes the former full extent of the Woodland Trail system, one of two areas in Shiawassee NWR that allows bike accessibility. Despite being a trail enjoyed in the past by visitors, the Marsh and River loops are now closed due to flooding issues along the Tittabawassee River. Areas of the primary Woodland Trail are also restricted due to fallen Ash trees and encroaching Common Buckthorn. Credit: Shiawassee NWR

Flooding, invasive species, and sensitive migratory species are a few of the several challenges that limit Shiawassee NWR's ability to implement extended bicycle accessibility throughout the expansive area of the refuge. Shiawassee NWR exemplifies some of the many limitations—both environmental as well as

fiscal when noting the high budgets necessary for materials and labor to maintain trails — that may stall or indefinitely delay bicycling initiatives on FWS land.

Looking Forward

As documented by the research and exemplified by the case studies, it is possible in some instances to accommodate bicycles in conservation areas while managing for impacts on wildlife, vegetation, and soils as well as maintenance and cost considerations. For some refuges, as highlighted by some of the case study examples, environmental and wildlife concerns may prevent or limit the ability of stations to provide bicycle access. The unique circumstances of each individual refuge highlighted in the case studies underscores the reality that there is no "one size fits all" solution with regards to implementing bicycle access and infrastructure throughout FWS managed lands (see Table 2). Each conserved habitat faces different needs as its collection of local flora and fauna may have different levels of tolerance for anthropogenic disturbance. To determine these needs, some refuges refer to existing literature regarding human involvement in the disturbance of habitats and species while others exhibit discretion based upon professional experience and anecdotal observation.

There is ample need for further research on this topic. Additional research is needed broadly on the impacts of bicycles on wildlife, vegetation, and soils, specifically as compared to hiking, considerations for new trail system design, human dimensions in trail design, and management and cost implications. Additionally, research is needed on the benefits and management implications of allowing bicycle access to and/or on refuges. The case studies illustrate how station managers are balancing the need to prioritize conservation of species and habitats while considering visitor experience holistically.

Bicycles are one mode by which visitors might get to and around a refuge. Combining bicycle access with access by foot and by car can accommodate a full range of visitation goals. For refuges that are unable to accommodate bicycle infrastructure due to environmental or wildlife conservation concerns, select case studies highlight how FWS stations can still serve as catalysts in their communities for bicycle infrastructure nearby refuge lands. Such refuges, while not directly maintaining bicycle infrastructure on station property, can still promote the benefits of bicycle infrastructure, which include but are not limited to increased visitor accessibility, greater physical activity, and lower dependency on automobiles resulting in lower carbon emissions.

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