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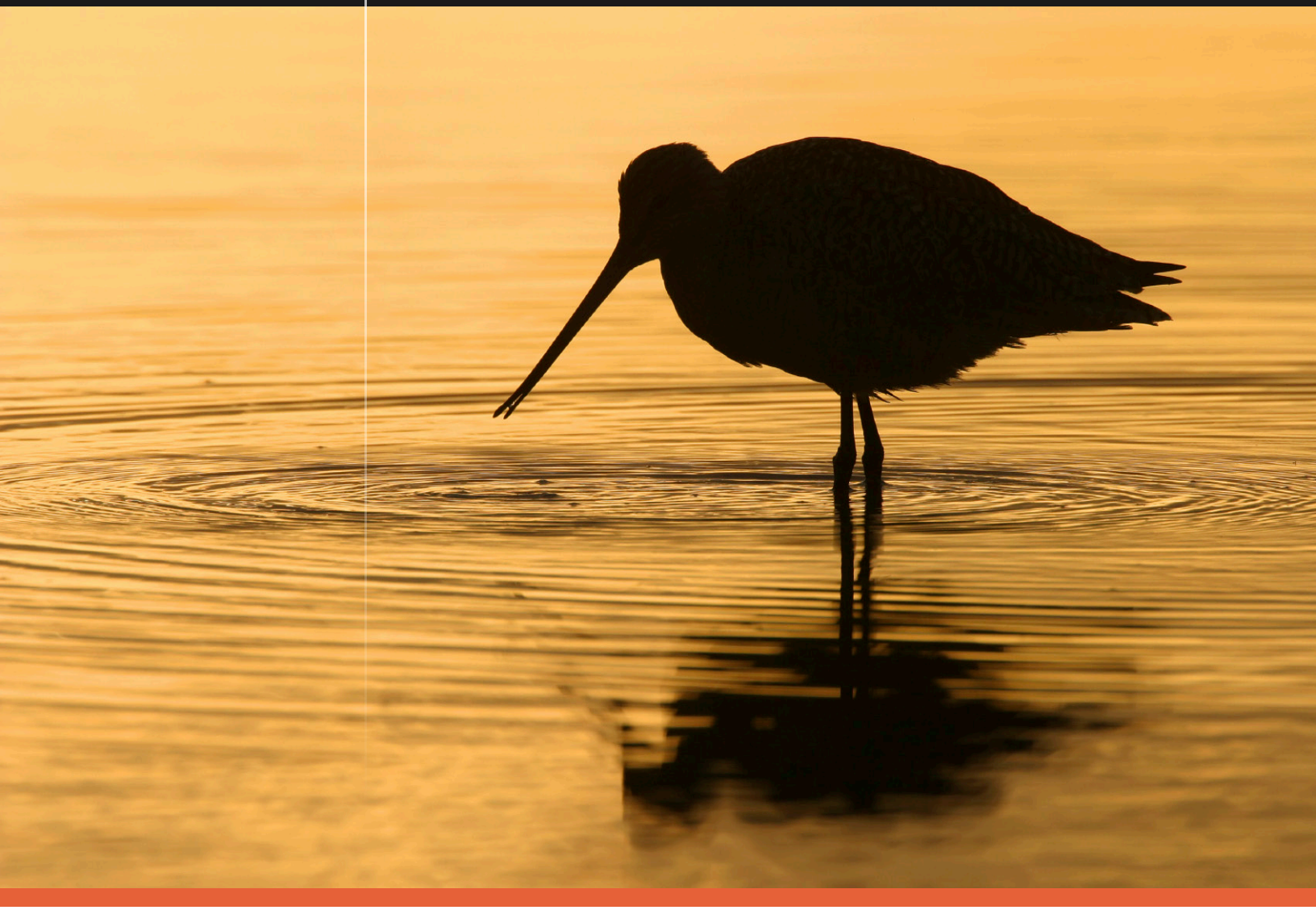

July 10, 2008

Stabilizing North American Shorebird Populations

A conservation strategy

Prepared for the David and Lucile Packard Foundation

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Summary

Ninety percent of North American Pacific coast shorebird species are declining in population, with many species suffering rapid declines

Ninety percent of North American Pacific coast shorebird species are declining in population, with many species suffering rapid declines. The Packard Foundation could potentially stabilize half of these species' populations with a budget of $20-25 M over 10 years.

The Foundation's goal is to reverse Pacific shorebird population declines

In North America, 28 of 31 species that depend on Pacific coast habitats are thought to be declining. The Packard Foundation's Marine Birds Initiative aims to stabilize as many of these species' populations as possible, with emphasis on site-based conservation to protect or improve areas important to these shorebird species. The potential geographic scope for these interventions is the entire Pacific coast from Alaska to Chile, with inland sites included if they are important to otherwise coastal species.

Many of these declines are believed to result from losses of migratory and wintering sites for shorebirds. The Foundation plans to focus on specific sites with a range of investments aimed at protecting, and in some cases restoring, important shorebird habitats. The Foundation also plans to make smaller investments in broader activities including scientific research and coordination of shorebird experts.

This goal can best be achieved by protecting a string of critical sites

The Foundation's best option to reduce population declines is to ensure the integrity of a "string of pearls" of critical sites along the Pacific coast. Sixteen such sites capture 80% of the most important areas for the 28 declining North American Pacific shorebird species (Figure 1). Five of these sites emerge as immediate priorities for conservation investment based on a threat analysis, a return-on-investment analysis, and interviews with shorebird experts, as described in the following chapter. These sites are Bahía Santa María, Mexico; Panama Bay, Panama; Chiloe Island, Chile; Grays Harbor, Washington; and the Central

Valley of California.

While each site's conservation needs are different, each requires a package of activities including a combination of the following:

1. Seek legal protection through government processes or land purchase/easement
2. Work with farmers and cities to reduce runoff pollution and hydrological alteration
3. Restore habitat, if needed
4. Build capacity of local partners, if needed
5. Develop long-term sea-level rise strategies

Very rough estimated costs of conservation at the sites range from $1-3 M at Chiloe Island to $15-20 M in the Central Valley of California. The Foundation can expect co-funders to cover 50-75% of the total cost at each site.

Figure 1. The string of pearls: 16 critical sites

Broader activities are also needed to achieve the goal

While the majority of the proposed budget is allocated to site-based conservation, some is reserved for broader activities and opportunistic granting (Figure 2). Broader work across sites is important given the exceptionally wide-ranging nature of migratory shorebirds.

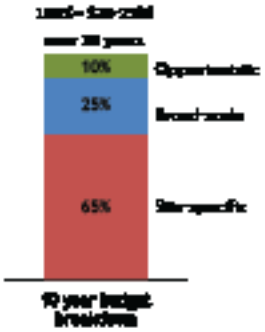
This proposed strategy includes funding for three sets of broader activities to complement the site-based work:

1. Establish a monitoring network (largely volunteer-based) covering all North America sites and key Latin America sites to measure changes in shorebird populations

2. Survey usage of North American Pacific shorebirds at poorly-understood sites in Peru, Costa Rica, and Suriname

3. Support networking of Latin American and North American shorebird conservationists by sponsoring attendance at conferences and workshops

Figure 2. Most of the budget is for site-specific conservation



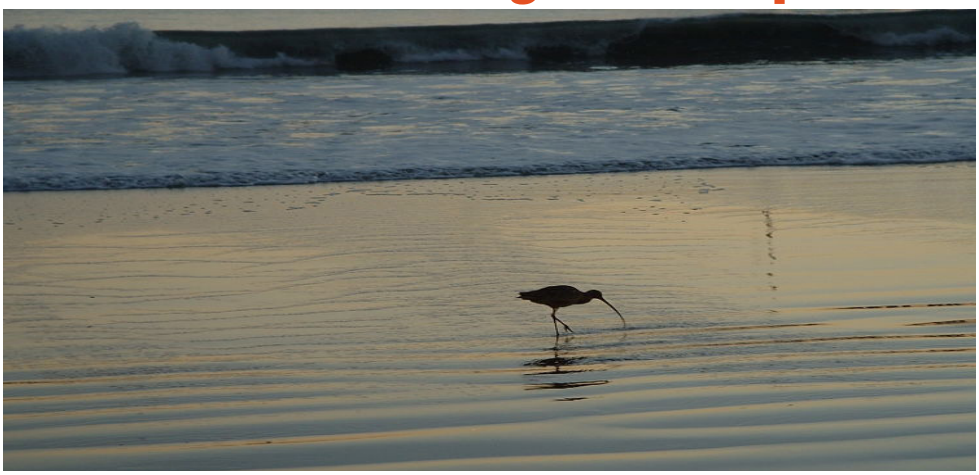
This can be implemented over 5 years with co-funding

For all types of spending, the Foundation can expect co-funders to cover about 50% of total costs in Latin America and about 75% of total costs in the United States. For domestic site-based work, the primary co-funders will be states and the federal government, with foundations and NGOs contributing additional funding. For Latin America site-based work, US government money is available through various cross-border wetland conservation initiatives. Foundations and NGOs are also likely to contribute. Additionally, the Mexican government is likely to provide funds for projects in Mexico. For broader activities, co-funding will come primarily from the US government and NGOs.

The Foundation should be able to complete many of the strategy's activities during the first five years of the initiative, assuming a budget of $2-2.5 million is available each year. The proposed timing for site-based work is to begin implementation at Bahía Santa María and the Central Valley during the first two years, and to reserve on-the-ground work in Panama Bay, Chiloe Island, and Grays Harbor for future years. For broader activities, the proposed activities for the first two years are to develop the monitoring network, survey proposed areas in Peru, Costa Rica, and Suriname, and sponsor 2-3 Latin American shorebird practitioners to attend the 2009 WHSRN meeting in Mazatlán, Mexico. In years 3-5 these activities could be expanded, especially the monitoring network.

1

1. Invest in the highest-impact



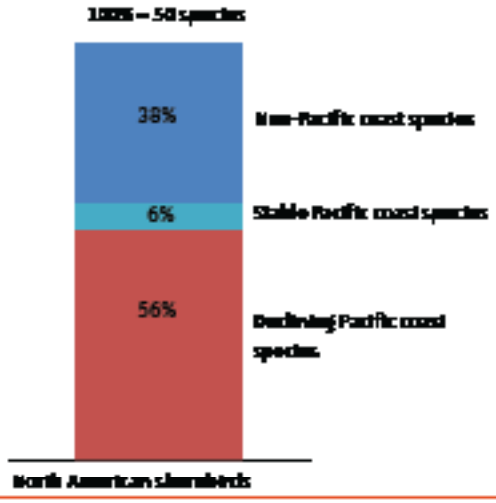
A string of critical sites along the Pacific coast are vital to reversing shorebird population declines

A string of critical sites along the Pacific coast are vital to reversing shorebird population declines. Most of the 28 declining North American Pacific species depend on 16 sites along the Pacific coast of the Americas. Five sites are particularly threatened, making them priorities for investment. These sites require protection even if, in extreme cases, alternate sites are needed in 50-100 years due to sea-level rise.

Action is needed to reverse declines of Pacific shorebirds

Of the 50 North American shorebird species, 31 use the Pacific coast for migration, wintering, or breeding. Of these, all but two are thought to be experiencing moderate to severe population declines (Figure 3). The full list of Pacific coast shorebird species is provided in Appendix 1.

Figure 3.
28 North American species depend on Pacific coast sites and are declining

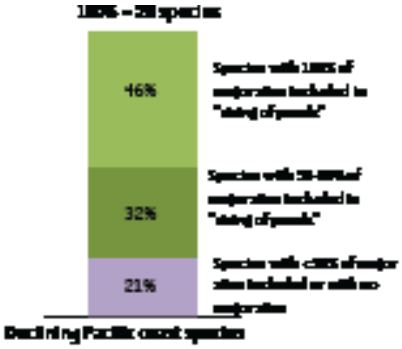


16 critical sites form a "string of pearls" along the coast

Sixteen of the over 200 breeding, stopover, and wintering sites used by North American Pacific shorebirds are disproportionately important. This string of pearls contains sites with peak counts of over 100,000 shorebirds in North America and over 50,000 shorebirds in Central and South America (Figure 1, previous section). Despite the variability in site use between species, the string of pearls contains most or all of the major sites for 80% of the 28 species of interest. Thirteen species have all of their major sites included and nine more have at least half of their major sites included (Figure 4)[1].

In addition to their critical importance for shorebirds, these coastal wetland sites have broader environmental and recreational values. They provide important habitat for a variety of species, including waterfowl and juvenile life phases of commercially important fishes. In addition, many of these sites are used for hiking, kayaking, bird watching, hunting, and other recreational activities.

Figure 4. Many species' major sites are included in the sixteen important Pacific coast sites



Some sites in the string need urgent conservation action

Taking into account threats and anticipated involvement of other funders at these 16 sites, five sites emerge as highest-priority for investment by the Foundation (Figure 5).

Nine of the 16 sites currently face limited threat. This includes breeding sites in remote parts of Alaska and Canada where the only significant threats may be oil spills (difficult to address) and long-term sea-level rise. These sites probably do not require immediate investment by the Foundation.

Two high-profile sites, San Francisco Bay and the Colorado River Delta, do face significant threats but are already being addressed by other funders. The San Francisco Bay Joint Venture is a coordinated group of government agencies and NGOs working to improve habitat conditions in San Francisco Bay for shorebirds and other waterbirds.

In the Colorado River Delta, a consortium of private funders, including the Packard Foundation, is funding habitat protection and restoration. Given these large

1 A major site has peak counts of at least 2% of a species' total estimated population.

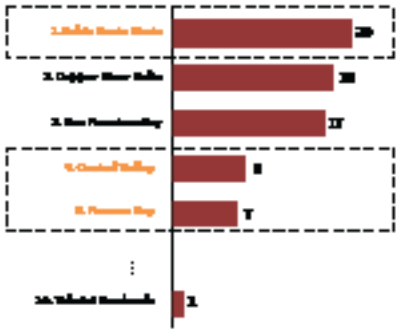
investments, moderate additions by the Foundation are unlikely to have a high impact at these two sites.

Figure 5. Breakdown of important sites

Five remaining threatened sites require conservation investments

Five remaining threatened sites require conservation investments: Grays Harbor, Washington; the Central Valley of California; Bahía Santa María, Mexico; Panama Bay, Panama; and Chiloe Island, Chile. Work at these sites is vital to preserve the integrity of the string of pearls. The case for action is made even stronger by the fact that three of the five sites are important to many species (Figure 6).

Figure 6. Three of the priority sites are among the most species-rich

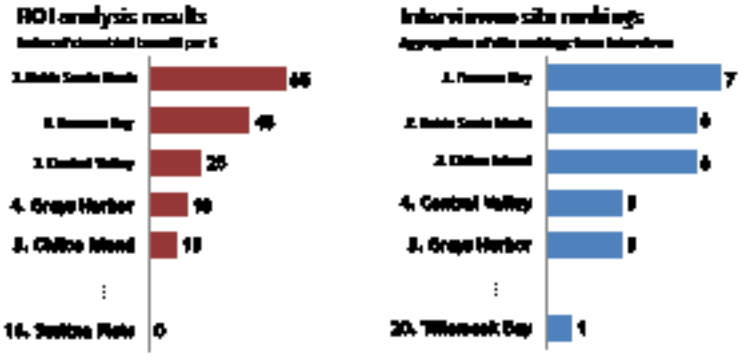


ROI analysis and interviews confirm these sites' importance

These priorities agree with the results of a return-on-investment analysis and interviews with shorebird experts. An ROI analysis of the 16 sites in the string of pearls ranked specific interventions at each site based on the expected reduction in threat, the total number of shorebirds to benefit, species diversity, the likelihood of the intervention succeeding, and the cost of the intervention (see Appendix 4 for a description of the ROI analysis). The same five sites identified above emerge as the five highest ROI sites (Figure 7). This is largely because of the relative magnitudes of threats (and therefore conservation opportunities) between sites.

In addition to the ROI analysis, 28 shorebird experts were interviewed about opportunities for site-based conservation. The five sites mentioned most frequently by experts were the same as the five highest ROI sites, although the ordering was slightly different (Figure 7). The consistency between the ROI and interview results suggests that these five sites are very strong candidates for conservation investment.

Figure 7. ROI and interview results are highly consistent



The potential outcome is 10-15 species' populations stabilized

Ensuring the integrity of the string of pearls, along with investments in broader activities, could potentially stabilize the populations of 10-15 declining North American Pacific shorebird species. This potential outcome is based on the 13 species whose major sites are completely contained within the String of Pearls. They are expected to benefit strongly.

As mentioned above, some activities beyond site-based conservation will be required to achieve this outcome. Proposed broader activities include monitoring of hemispheric shorebird populations, surveying of poorly-understood sites in Latin America, and coordination of shorebird conservationists. These strategies are described graphically in the proposed program logic model (Figure 8).

Figure 8. Proposed logic model

Sea-level rise requires further planning and mitigation

In the long-term, sea-level rise due to climate change threatens shorebird habitat at all coastal sites. Adaptation to sea-level rise depends on the ability of intertidal habitats to migrate inland. Inland migration may be easiest in undeveloped areas (including farms), because dikes can be removed to flood upland areas as seas rise. Urbanization limits inland migration because intentional flooding of developed land is unlikely to be accepted.

Detailed studies of potential sea-level rise should be carried out at all of the priority sites. However, even if critical sites are likely to be degraded in 50-100 years, these sites are probably so important to shorebird populations in the medium term that protection will be required until alternate sites can be identified and protected or restored.

2

2. Design the right conservation package at each site

The five threatened sites require a package of protection, restoration, water management, and stronger local conservation capacity

Each of the five threatened sites in the string of pearls requires a package of legal protection, habitat restoration, water management, and strengthening of local conservation capacity. The estimated total costs to meet all of these conservation needs range from $1-3 M for Chiloe Island to $15-20M for the Central Valley of California.

Bahía Santa María, Mexico

Overview

Wetlands in Sinaloa, Sonora, and Baja California are important stopover and wintering sites for the Foundation's species of interest. The Bahía Santa María area stands out among the several important sites in this region. Bahía Santa María proper (BSM) and nearby Laguna Chirihueto in Ensenada Pabellones (EP) together receive over 800,000 shorebirds per day in winter. They hold 30% of the shorebirds that winter on the North American Pacific coast. Other sites, such as Guerrero Negro on the Baja Peninsula and Marismas Nacionales in Sinaloa, also receive substantial numbers of shorebirds; however,

the threat at these sites is generally less than the threat at BSM and EP.

Threats

Agriculture is the primary threat to shorebirds at BSM/EP. Agriculture harms shorebird habitat in three ways. Polluted farm runoff carries chemicals and nutrients into the sites, invasive cattail plants reduce available shorebird habitat (due to nutrient pollution), and drainage ditches dry out wetlands by blocking cross-flow of water.

Shrimp aquaculture also harms shorebird sites through water pollution and hydrological alteration. However, the extent of shrimp farms is small compared to agriculture. Because of its relatively small scale in the region, it is probably not necessary to address aquaculture to protect shorebirds at this site.

The potential to adapt to sea-level rise at this site may be relatively high, as most upland areas are in agriculture.

Capacity

Capacity for shorebird conservation is relatively high in this region. The Western Hemisphere Shorebird Reserve Network (WHSRN), Pronatura Noroeste, and Universidad Autonoma de Mazatlán are all active on shorebird issues in this region. Pronatura and WHSRN have even secured some funds from the American Bird Conservancy and the US and Mexican governments for initial conservation activities. In addition to this high level of NGO engagement, the National Commission for Natural Protected Areas (CONANP) supports designation of these sites as Natural Protected Areas (NPAs).

Conservation package

A conservation package for BSM and EP could cost about $4-6 M total, with an expected Packard contribution of $2-3 M. It could include the following components:

4. **Have an NGO shepherd NPA designations at both sites.** Having an NGO lead site surveys, public hearings, and other process steps will increase the probability of achieving the designations. NPA status will increase government funding for conservation at the site, and is therefore a worthwhile pursuit.

However, the direct conservation benefit is unclear, as NPA rules are created on a site-specific basis.

5. **Filter agricultural runoff entering the sites from the largest drainage canals.** Given the importance of agriculture and the lack of advocacy capacity to change policy, reducing chemical use is probably a non-starter. The best option to improve water quality is to filter water from a few large drainage canals. Working with irrigation districts or the water authority to identify the paths and amounts of chemicals entering the sites will be critical, along with pilot studies on smaller drainage canals to identify the best methods to clean runoff water.
6. **Consider using pipes to connect tidal and freshwater flow to areas blocked by drainage canals**. Large habitat areas could be restored by bridging water over or under drainage canals, which block cross-flow. However, more information is needed on whether this would reduce the total volume of water reaching the bays.
7. **Remove cattails mechanically once a plan is developed for on-going control.** WHSRN and Pronatura believe that cattails can be eradicated with heavy equipment. The organizations should purchase the machinery (expected to cost $500K) and restore sites in sequence. Following removal, monitoring and possibly chemical control will be needed to prevent reinvasion.

Panama Bay, Panama

Overview

Panama Bay is a critical stopover and wintering site used by over 1 M shorebirds. About 90% of the shorebird use occurs at two areas in the upper bay: Costa del Este and Rio Pacora. The entire bay was declared a Hemispheric WHSRN site in 2005, which created momentum for conservation in the area.

Threats

Both Costa del Este and Rio Pacora are highly threatened by urban development.

Development drives mangrove clearing near the site, which reduces food supply in the mudflats and could threaten the hydrological dynamic that maintains the wide extent of habitat. The intertidal areas are publicly owned and loosely protected, but pressure to develop in or near those areas could increase as the city grows. An additional possible threat is runoff from farms further away from the city.

Urban development also limits the ability of intertidal habitats to migrate inland as the sea rises at this site. Costa del Este, which fronts the city, could eventually suffer severe habitat loss for this reason. The mudflats at Rio Pacora may be better able to adapt, since the uplands in that area may be less developed.

Capacity

Conservation capacity in Panama Bay is limited compared to the other priority sites

Conservation capacity in Panama Bay is limited compared to the other priority sites. There are three organizations interested in conservation in the Bay, but none has the current capacity to take the lead. Panama Audubon Society is a mostly-volunteer organization with a limited staff. The mayor of Panama City and the national environment ministry support conservation in the Bay, but have not taken action beyond the WHSRN designation. The Panama Canal Authority is a potential partner for technical studies of hydrology and sea-level rise. A fourth potential partner could be The Nature Conservancy's Migratory Birds program, which has expressed some interest in working here (but does not have a presence currently).

Conservation package

A conservation package for Panama Bay could cost about $4-8 M, with a Packard contribution of $2-4 M. It could include the following steps:

First, build capacity of local NGOs (possibly Panama Audubon Society). A strong local partner is needed to undertake the potentially challenging advocacy work required here.

Consider seeking stricter legal protection for the mudflats. The intertidal mudflats of Panama Bay are publicly-owned, but stricter protection (added to the area's non-binding WHSRN site status) could further reduce the threat of development.

Reduce mangrove clearing by purchasing land/easements or improving law enforcement. Clearing of mangroves is illegal, but the law is relatively poorly enforced.

If water pollution is a problem, filter water or work with farmers and the city to reduce inputs. Further study is needed to evaluate the threat posed by urban and agricultural runoff here.

Chiloe Island, Chile

Overview

Chiloe Island is a wintering site of vital importance to the Pacific populations of two long-distance migrants: Hudsonian godwits and whimbrels. Both are listed as species of high conservation concern in the US Shorebird Conservation plan. On Chiloe Island, these species are concentrated in two small bays, Pullao and Putemún (Figure 9). While Chiloe benefits fewer species than the other priority sites, it is attractive because of its critical importance to the 2 threatened species that use it, its near-pristine condition, and the low estimated cost of conservation.

Threats

The main threats to Chiloe Island's shorebirds are prospective, but imminent. There is therefore an opportunity to protect intact habitat before significant degradation occurs. The primary looming threat is aquaculture. Salmon farming and algae growing are both poised to expand into the bays used by the godwits and whimbrels. Additionally, coastal development is also possible. The coastal land around Pullao is entirely held by 2-3 owners, but subdivision and development may occur if this opportunity to protect land is missed.

The area's potential to adapt to sea-level rise is probably high, since much of the uplands in the area are agricultural.

Figure 9. Important areas on Chiloe Island

Capacity

Capacity for shorebird conservation at Chiloe is developing but still limited. Chiloe Bird Observatory (CBO) is a small science-focused NGO. They could be a potential partner, especially for research and planning. CODEFF, Birdlife International's partner in Chile, is another possible partner. However, they do not currently work on Chiloe Island.

Conservation package

A conservation package for Chiloe Island could cost about $1-3 M, with a Packard contribution of about $0.5-1.5 M. It could include the following steps:

Build capacity of local NGOs (probably CBO or CODEFF). CBO is a young organization; CODEFF is an established group but lacks specific knowledge of Chiloe Island.

Buy land or rights to land in Pullao. Putting habitat into protection before development occurs will secure the value of this highly intact site.

Work to prevent aquaculture development in Pullao and Putemún. The Chilean Navy controls permitting for aquaculture on the island. Securing the Navy's commitment not

to allow harmful aquaculture development at Pullao and Putemún is key to conservation here.

Central Valley Complex, California

Overview

The Central Valley of California is important for several migrating and wintering Pacific coast shorebird species. The area has peak counts of 500,000 shorebirds. While 95% of wetlands and 90% of riparian habitat have been destroyed or modified in this area, flooded agricultural lands make good shorebird habitats. The prevalence of rice fields in the Central Valley creates an opportunity to manage an important shorebird site without having to purchase and restore large areas of expensive land.

Threats

The principal problem for shorebirds in this region (setting aside past wetland losses) is mistimed flooding of rice fields. Migrating and wintering shorebirds require some fields to be held at appropriate foraging depths throughout fall, winter, and spring. Farmers have some flexibility in when they flood fields. It should be possible to coordinate flooding schedules through a combination of public outreach and incentive payments. There may be an opportunity to piggy-back on carbon offset payments to rice growers who periodically drain their fields to reduce methane emissions.

The threat from sea-level rise here is obviously low, but climate change may have other hydrological impacts in the Central Valley that deserve study.

Capacity

Capacity for shorebird conservation in the Central Valley Complex is relatively high. The Central California Joint Venture (CCJV) and Ducks Unlimited (DU) have done extensive conservation planning for shorebirds. In addition, National Audubon and TNC are also active here.

Capacity for shorebird conservation in the Central Valley Complex is relatively high

Conservation package

A conservation package for the Central Valley could cost about $15-20 M, with a Packard contribution of about $3-5 M. It could include the following steps:

Work with farmers to coordinate flooding schedules for rice fields. Manage flooding schedules so that the necessary amount of appropriately-flooded habitat is available throughout the fall, winter, and spring to support migrating and wintering shorebirds. CCJV and DU have calculated the extent of fields required in different parts of the Central Valley to accomplish this goal.

Purchase and restore a small area of seasonal wetlands. While water management on rice fields is the primary focus, some wetland restoration is also required. The CCJV shorebird plan sets specific restoration targets for different areas of the valley.

Grays Harbor, Washington

Overview

Grays Harbor is an important stopover site for over 1 M migrating shorebirds. The majority of shorebird use occurs in 3 areas: Bowerman Basin, Humptulips Estuary, and Bottle Beach. In general, Gray's Harbor is less threatened than the other 4 priority sites.

Bowerman Basin and Humptulips Estuary are included in the Grays Harbor National Wildlife Refuge, which offers some protection for shorebirds. In addition, activities such as agriculture and forest clearing are more regulated here than at other sites. However, expanding upstream urban development and the threat of invasion by *Spartina* and other invasive plants require conservation investments at this site.

Threats

The main threats to shorebirds come from urban development and from potential introductions of invasive plants. Urban areas around Grays Harbor are growing, with potential impacts on the quality and quantity of water reaching shorebird habitats. Additionally, some lands adjoining Bowerman Basin are zoned for heavy industrial development. While previous proposals to develop these lands have been withdrawn, there is a persistent small possibility that plans will be revived.

Figure 10. Important areas in Grays Harbor

The threat of *Spartina* invasion is fairly serious at Grays Harbor. This plant greatly reduces the value of foraging habitats for shorebirds. The plant is already present at the site, but it has not become established on a large scale. Nearby Willapa Bay, where shorebird habitats have suffered severe degradation due to Spartina, illustrates the possible effects of the plant (though eradication is now proceeding at Willapa Bay).

The area's ability to adapt to sea-level rise is unclear, as uplands are partially developed, and development is increasing.

In Grays Harbor there is broad public interest in shorebirds

Capacity

Capacity for shorebird conservation in Grays Harbor is relatively high. Several conservation organizations and government agencies (including the national wildlife refuge) are active here. In addition to these professional groups, there is broad public interest in shorebirds. For example, a national shorebird festival is held here every year during spring.

Conservation package

A conservation package for Grays Harbor could cost about $6-8 M, with a potential Packard contribution of $3-4 M. It could include the following steps:

Finish removing Spartina and prevent re-invasion. This eradication and bio-security campaign should focus on Bowerman Basin, Humptulips Estuary, and Bottle Beach.

Monitor water quality and flows, and work with communities to improve water management if necessary. Understanding the potential impacts of urban development on water quality and flows is important to judge whether conservation action is required. If needed, potential actions could include building additional water treatment capacity, channeling runoff away from important shorebird sites, or re-allocating water rights so that sufficient water reaches the sites.

Continue to prevent possible industrial development near Bowerman Basin. Working with advocacy groups to monitor potential development proposals will enable quick action to protect the site. Changing the zoning of land near the site could offer more permanent protection.

3

3. Split spending between site-based and broader work

Broader activities such as scientific research and coordination of practitioners are also important to achieving the program outcome

Broader activities such as scientific research and coordination of practitioners are also important to achieving the program outcome. These types of activities are about 25% of the program budget. For all types of spending, the Foundation should expect significant co-funding from partners including governments, NGOs, and other foundations.

Most funding is for site-based conservation

The site-specific activities described in the previous chapter are expected to account for about 65% of the program budget (Figure 2).

Broader activities account for 25% of the budget

About 25% of the budget is dedicated to three specific sets of broader activities: shorebird population monitoring, surveying of poorly-studied sites in Central and South America, and networking of Latin American and US/Canadian practitioners to coordinate conservation activities across these species' wide ranges.

Monitor population trends

The primary activity in this category is to fund a Pacific coast-wide monitoring initiative to track overall shorebird population trends. Lack of knowledge in this area limits understanding of the causes of shorebird declines (and hopefully recoveries). In the United States the network could be volunteer-driven and cover the majority of Pacific coast sites. In Latin America it may need to be a professional effort focused on a few major sites (including Bahía Santa María, Panama Bay, and Chiloe Island).

Survey additional sites in Central and South America

Shorebird use in certain parts of Latin America is currently poorly understood. The Foundation could fund research to better document these sites' importance to North

American Pacific shorebirds. Priority regions include the northern coast of Peru, the Gulf of Nicoya in Costa Rica, where new reports have indicated potential concentrations of shorebirds, and the coast of Suriname, where information is needed on site usage by Pacific species. Overflight studies to gather rough count data may be sufficient in Peru and Costa Rica. On-the-ground work is probably required to understand Suriname's importance to Pacific species. Potential projects in Suriname could be coordinated through Rob Clay of Birdlife International and David Mizrahi of New Jersey Audubon.

Encourage networking of Latin American shorebird conservationists

With the exception of Mexico and possibly Colombia, shorebird practitioners in Latin America have limited connections to the more established network of shorebird researchers and conservationists in the United States and Canada. The Foundation could sponsor Latin American shorebird practitioners to attend major shorebird conferences, such as the WHSRN meeting in Mazatlán in 2009.

Opportunistic granting accounts for 10% of the budget

About 10% of the program budget is reserved for outstanding opportunities outside of the activities described in this strategy. Examples of past opportunistic grants include a grant to monitor the impacts of a major seawall project in South Korea expected to negatively affect shorebirds, and a grant to radio-track long-distance migrants such as the bar-tailed godwit and the bristle-thighed curlew.

Additional money could fund more sites or advocacy

With additional funding, the program could invest in conservation at important smaller sites, or in advocacy to increase government funding for shorebird conservation. Figure 11 shows smaller, high-ROI sites outside of the string of pearls where site-based conservation would have additional benefits for shorebirds.

If, instead, the Foundation were to direct the additional funds to advocacy, at least two potentially high-return campaigns could be undertaken. First, the Foundation could fund efforts to increase federal funding for the North American Wetlands Conservation Act (NAWCA) and the Neotropical Migratory Bird Conservation Act (NMBCA). Both of these programs support coastal wetlands conservation in the US and Latin America. Alternately, the Foundation could fund efforts to broaden federal coastal wetlands grants to allow activities above the current high tide line. This would allow these grant funds to be used for sea-level rise planning and mitigation.

The program can expect about a 3:1 match for projects within the United States, and a 1:1 match for projects in Latin America

Potential funding partners exist for all activities

The program can expect about a 3:1 match for projects within the United States, and a 1:1 match for projects in Latin America. In addition to the potential co-funders described below, there may be overlap with other Packard Foundation programs in the Central Valley (Western Lands) and Bahía Santa María (Gulf of California program). Appendix 3 lists specific potential co-funders for each of the five priority sites.

Figure 11. Additional small sites

Domestic site-based work

Most co-funding for these sites will come from federal and state governments through NAWCA, coastal wetland grants, state bonds, and joint ventures. Wetland-focused foundations and NGOs may also contribute. Wetland- and waterbird-focused NGOs in the US have significant expertise in raising matching funds from the federal government. The Foundation could collaborate with these groups to design funding packages for each that maximize federal contributions.

Latin America site-based work

US funding is available through NAWCA (for sites in Mexico) and NMBCA. Foundations and NGOs may contribute additional funding. The governments of the countries where sites are located could also provide some funding, particularly the Mexican federal government.

Broader work

Co-funding sources for monitoring and surveying include agencies (USFWS, USGS) and NGOs (Manomet, PRBO). Since these groups have existing investments in smaller-scale shorebird monitoring, they could be excited to participate in the creation of a more comprehensive network.

For networking of shorebird practitioners, NGOs such as Manomet, WHSRN, and PRBO could also be potential partners. These groups organize a number of meetings for shorebird researchers and conservationists (for example, the 2009 WHSRN meeting in Maztlán, Mexico). These NGOs may co-sponsor Latin American researchers to attend their events.

4

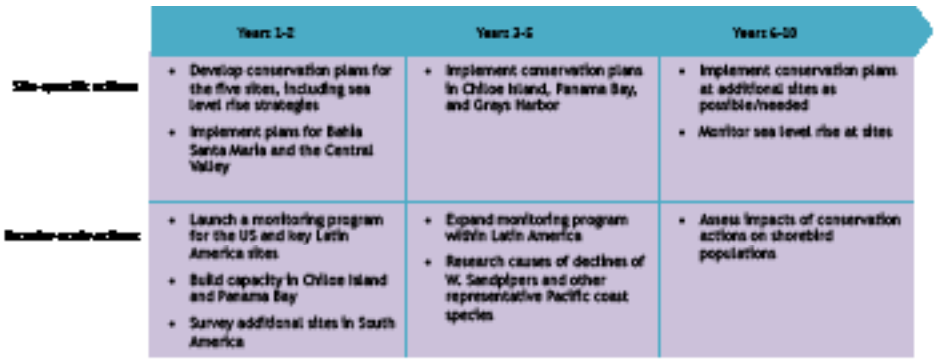
A possible implementation plan begins with site-based work at sites that are ready

4. Implement the strategy over five years

A possible implementation plan begins with site-based work at sites that are ready, capacity building and planning at the remaining sites, and development of a Pacific coast shorebird monitoring network.

For site-based activities, work during the first two years could focus on implementation at Bahía Santa María and the Central Valley of California, and on capacity building or planning at the other three priority sites. Implementation at the latter three sites could occur in years 3-5. For broader activities, work during the first two years could focus on establishing a monitoring network at US and key Latin America sites and on surveying additional sites in Peru, Suriname, and Costa Rica. Broader work in years 3-5 could be dedicated to expanding the monitoring network in Latin America if possible (Figure 12).

Figure 12. Possible implementation plan



A1

Appendix 1: North American Pacific shorebird species

Pacific coast species were defined as species that depend primarily on Pacific coast sites for breeding, migration, or wintering (assessed using the US Shorebird Conservation Plan). Birds using primarily central or eastern sites in North America were not included even if they used Pacific sites in Latin America. However, long-distance migrants that may not use any North American stopover sites were included if they depended on Pacific coast sites in Latin America (eg., Hudsonian godwit). This led to a list of 31 Pacific Coast species.

The US shorebird conservation plan rates population declines on a 1–5 scale (5 = severe decline). In this strategy, species with scores of at least 3 ("moderate concern") were considered declining. Of the 31 Pacific Coast species, 28 are declining.

Declining N.A. Pacific species	Population trend score
American Avocet	3
Black Oystercatcher	3
Black Turnstone	3
Black-bellied Plover	5
Black-necked Stilt	3
Dunlin	5
Greater Yellowlegs	3
Hudsonian Godwit	3
Killdeer	5
Least Sandpiper	5
Lesser Yellowlegs	5
Long-billed Curlew	5
Long-billed dowitcher	2
Marbled Godwit	4
Red Knot	5
Red Phalarope	5
Red-necked Phalarope	4
Rock Sandpiper	3
Ruddy Turnstone	4
Sanderling	5
Semipalmated Plover	3
Short-billed dowitcher	5
Snowy Plover	5
Spotted Sandpiper	3

Surfbird	4
Western Sandpiper	5
Whimbrel	5
Willet	3
Wilson's Phalarope	5

Stable N.A. Pacific species	Population trend score
Common snipe	2
Long-billed dowitcher	2
Wilson's Dowitcher	NA

A2

Appendix 2: List of all sites considered

The 281 sites on this list were compiled from the WHSRN sites database; Important Bird Area databases for the US, Canada, Mexico, Panama, Ecuador, Colombia, Peru, and Bolivia; the US Shorebird Conservation Plan and regional plans; the Canadian shorebird conservation plan; scientific papers; expert input; and other sources.

Country	State/Province (if US or Canada)	Site Name
Argentina		Bahía de San Antonio
Argentina		Costa Atlántica de Tierra del Fuego
Argentina		Estuario del río Gallegos
Argentina		Laguna Mar Chiquita
Brazil		Lagoa do Peixe
Brazil		Reentrâncias Maranhenses
Canada	British Columbia	Barkley Sound
Canada	British Columbia	Baynes Sound
Canada	British Columbia	Clayoquot Sound
Canada	British Columbia	Fraser River Estuary
Canada	British Columbia	Kyuquot Channel Islands
Canada	British Columbia	McIntyre Beach and Rose Spit
Canada	British Columbia	Moore and Byers Islands
Canada	British Columbia	Tofino Mudflats
Canada	British Columbia	Wilson Creek
Canada	Yukon	Blow River Delta (shingle Point to Tent Island)
Canada	Yukon	Nunaluk Spit to Herschel Island
Chile		Chiloe Island
Colombia		Delta del Rio San Juan
Colombia		Parque Nacional Natural Gorgona
Colombia		Parque Nacional Natural Sanquianga
Costa Rica		Gulf of Nicoya
Ecuador		Lagunas de Ecuasal
Ecuador		Archipiélago de Jambelí
Ecuador		Cienaga de La Segua
Ecuador		Humedales de Pacoa
Ecuador		Humedales del Sur de Isabela
Ecuador		Reserva Ecológica Arenillas
Ecuador		Reserva Ecológica Manglares-Churute
Mexico		Ensenada de la Paz
Mexico		Guerrero Negro

Country	State/Province (if US or Canada)	Site Name
Mexico		Marismas Nacionales
Mexico		Llano de la Soledad
Mexico		Bahía de Santa maria
Mexico		Ensenada de Pabellones
Mexico		Playa Ceuta
Mexico		Delta del Rio Colorado
Mexico		Lago Texcoco
Mexico		Playa Ceuta
Mexico		Bahía de Caimanero
Mexico		Bahía de Guaymas
Mexico		Bahía de Kino
Mexico		Bahía de Santa Barbara
Mexico		Bahía de Topolobambo
Mexico		Bahía Guadalupana
Mexico		Bahía Magdalena-Almejas
Mexico		Bahía San Quintín
Mexico		Complejo Lagunar Ojo de Liebre
Mexico		Estero de San José
Mexico		Estero del Soldado
Mexico		Estero Lobos
Mexico		Isla San Idelfonso
Mexico		Isla Tobari
Mexico		La Encrucijada
Mexico		Puerto Pen~ascos
Mexico		Sistema Lagunario Huizache-Caimanero
Mexico		Sistema Tóbari
Mexico		Zonas Húmedas de Yávaros
Mexico-United States		Laguna Madre
Panama		Upper Bay of Panama
Paraguay		Bahía de Asunción
Peru		Reserva Nacional de Paracas
Peru		Laguna Umayo
Peru		Pantanos de Villa
Suriname		Bigi Pan
Suriname		Coppenamemonding
Suriname		Wia Wia
United States	Alaska	Andreafsky Wilderness
United States	Alaska	Carter Bay
United States	Alaska	Central Seward Peninsula

Country	State/Province (if US or Canada)	Site Name
United States	Alaska	Central Yukon-Kuskokwim
United States	Alaska	Cinder River-Hook Lagoon
United States	Alaska	Cook Inlet
United States	Alaska	Copper River Delta
United States	Alaska	Egegik Bay
United States	Alaska	Gareloi Island
United States	Alaska	Goodnews Bay
United States	Alaska	Kachemak Bay
United States	Alaska	Kiska Island
United States	Alaska	Kuskokwim Bay, Marine
United States	Alaska	Kvichak Bay
United States	Alaska	Mendenhall Wetlands
United States	Alaska	Nelson Lagoon-Mud Bay
United States	Alaska	Northern Montague Island
United States	Alaska	Norton Bay
United States	Alaska	Nunivak Island
United States	Alaska	Nushagak Bay
United States	Alaska	Port Heiden
United States	Alaska	Redoubt Bay
United States	Alaska	Seal Islands
United States	Alaska	Stikine River Delta
United States	Alaska	Susitna Flats
United States	Alaska	Teshekpuk Lake-E. Dease Inlet
United States	Alaska	Trading Bay
United States	Alaska	Tuxdeni Bay
United States	Alaska	Ugashik Bay
United States	Alaska	Yakutat Forelands
United States	Alaska	Yukon-Kuskokwim (YK) Delta
United States	Arizona	Anderson Mesa
United States	Arizona	Bill Williams River National Wildlife Refuge
United States	California	Abbotts Lagoon
United States	California	Agua Hedionda lagoon
United States	California	Alameda naval Air Station
United States	California	Antelope Valley
United States	California	Batiquitos Lagoon
United States	California	Benicia State Recreation Area
United States	California	Big Valley/Ash Creek
United States	California	Bodega Bay
United States	California	Bolinas Lagoon

Country	State/Province (if US or Canada)	Site Name
United States	California	Bolsa Chica
United States	California	Bolsa de San Felipe
United States	California	Buena Vista lake Bed
United States	California	Byron Area
United States	California	Camp Pendleton/Santa Margarita River
United States	California	Carrizo Plain
United States	California	Concord Marshes
United States	California	Cosumnes River Preserve
United States	California	Creighton Ranch
United States	California	Cuyama Valley
United States	California	Devereux Slough
United States	California	Drakes and Limantour Esteros
United States	California	Eastshore Wetlands
United States	California	Edwards Air Force Base
United States	California	Elkhorn Slough
United States	California	Estero Americano
United States	California	Fall River Valley Area
United States	California	Goleta Slough
United States	California	Goose Lake, Kern Co.
United States	California	Goose Lake, Modoc Co.
United States	California	Grasslands
United States	California	Humboldt Bay Complex
United States	California	Imperial Valley
United States	California	Jepson Grasslands
United States	California	Kern National Wildlife Refuge
United States	California	Klamath Basin/Clear Lake
United States	California	LaGrange-Waterford Grasslands
United States	California	Lone Willow Slough
United States	California	Los Angeles River Estuary
United States	California	Los Penasquitos lagoon
United States	California	Lower Colorado River Valley
United States	California	Malibu lagoon
United States	California	Mendota Wildlife Refuge
United States	California	Merced Grasslands
United States	California	Mission Bay & San Diego Flood Control Channel
United States	California	Modoc National Wildlife Refuge
United States	California	Mono Lake
United States	California	Morro Bay
United States	California	Mugu lagoon

Country	State/Province (if US or Canada)	Site Name
United States	California	North San Diego Lagoons
United States	California	Orange Coast Wetlands
United States	California	Pajaro River Estuary
United States	California	Panoche Valley
United States	California	Pixley National Wildlife Refuge
United States	California	Point Reyes
United States	California	Richardson Bay
United States	California	Sacramento Valley
United States	California	Sacramento-San Joaquin Delta
United States	California	Salinas River-Lower
United States	California	San Diego Bay (or South San Diego Bay)
United States	California	San Diego National Wildlife Refuge-Eastern
United States	California	San Dieguito Lagoon
United States	California	San Elijo Lagoon
United States	California	San Francisco Bay
United States	California	San Gabriel River Estuary
United States	California	San Jacinto Valley
United States	California	San Joaquin Marsh
United States	California	Santa Ana River Mouth
United States	California	Santa Margarita River Estuary
United States	California	Santa Maria River Estuary
United States	California	Seal Beach National Wildlife Refuge
United States	California	Sierra Valley
United States	California	Smith River Estuary
United States	California	Sonny Bono Salton Sea National Wildlife Refuge
United States	California	Stone lakes National Wildlife Refuge
United States	California	Suisun Marsh
United States	California	Surprise Valley
United States	California	Talawa Lake
United States	California	Tijuana River Estuary
United States	California	Tomales Bay
United States	California	Tulare lake Bed
United States	California	Upper Newport Bay
United States	California	Vandenberg Air Force Base
United States	California	Yolo Bypass Area
United States	Idaho	Springfield Bottoms / American Falls Reservoir
United States	Oregon	Alsea Bay
United States	Oregon	Ankeney National Wildlife Refuge
United States	Oregon	Bandon Marsh National Wildlife Refuge

Country	State/Province (if US or Canada)	Site Name
United States	Oregon	Baskett Slough National Wildlife Refuge
United States	Oregon	Bayocean Spit
United States	Oregon	Boardman Grasslands
United States	Oregon	Brownsville ricefields
United States	Oregon	Bybee Lake
United States	Oregon	Cape Blanco
United States	Oregon	Clatsop Beach
United States	Oregon	Columbia River Estuary
United States	Oregon	Columbia River to Siletz Bay
United States	Oregon	Coos Bay
United States	Oregon	Coos Bay to California border
United States	Oregon	Coquille River to Cape Blanco
United States	Oregon	Damon Point
United States	Oregon	E.E. Wilson WMA
United States	Oregon	Fern Ridge Reservoir
United States	Oregon	Grayland Beach
United States	Oregon	Green Island
United States	Oregon	Haceta Head to Siuslaw River
United States	Oregon	Horsfall Beach to Coos Bay
United States	Oregon	Lake Labish
United States	Oregon	Lois Island
United States	Oregon	Long Island
United States	Oregon	Medford
United States	Oregon	Miller Island Spit
United States	Oregon	Nehalem Bay
United States	Oregon	Netarts Bay
United States	Oregon	New River Estuary
United States	Oregon	North Beach [Longbeach]
United States	Oregon	OceanShores/ Copalis Beach
United States	Oregon	Oregon Dunes National Recreation Area
United States	Oregon	Piller Rock
United States	Oregon	Quinn Island
United States	Oregon	Roseburg-Sutherlin
United States	Oregon	Russian Island
United States	Oregon	San Juan Islands National Wildlife Refuge
United States	Oregon	Sauvie Island
United States	Oregon	Siletz Bay
United States	Oregon	Siletz Bay to Coos Bay
United States	Oregon	Siuslaw River Estuary

Country	State/Province (if US or Canada)	Site Name
United States	Oregon	Smith Lake
United States	Oregon	Snag Island (CRiver Estuary)
United States	Oregon	Strait of Juan de Fuca
United States	Oregon	Sunset Beach
United States	Oregon	Tenmile
United States	Oregon	Tillamook Bay
United States	Oregon	Trestle Bay - Clatsop Spit
United States	Oregon	Washington Maritime National Wildlife Refuge
United States	Oregon	West Eugene wetlands
United States	Oregon	William L. Finley National Wildlife Refuge
United States	Oregon	Yachats to Seal Rock
United States	Oregon	Yaquina Bay
United States	Oregon/CA	Smith River Estuary
United States	South Carolina	Cape Romain National Wildlife Refuge
United States	Utah	Great Salt Lake
United States	Washington	Ala Spit
United States	Washington	Annas Bay
United States	Washington	Baker Bay
United States	Washington	Bellingham Bay
United States	Washington	Birch Bay
United States	Washington	Boz Lake
United States	Washington	Chehalis River Valley
United States	Washington	Chuckanut Bay
United States	Washington	Columbia Hills
United States	Washington	Columbia River
United States	Washington	Crockett Lake
United States	Washington	Cultus Bay
United States	Washington	Deer Lagoon
United States	Washington	Drayton Harbor
United States	Washington	Dungeness Bay
United States	Washington	Eld Inlet
United States	Washington	Fidalgo Bay
United States	Washington	Fitzner-Eberhardt Arid Lands Ecology Reserve
United States	Washington	Grays Harbor Estuary
United States	Washington	Hanford Ranch
United States	Washington	Kilisut Harbor
United States	Washington	Lummi Bay
United States	Washington	Nisqually River Delta
United States	Washington	North Potholes Preserve

Country	State/Province (if US or Canada)	Site Name
United States	Washington	Oak Bay
United States	Washington	Padilla Bay
United States	Washington	Port Angeles Harbor
United States	Washington	Port Susan
United States	Washington	Samish Bay
United States	Washington	Sequim Bay
United States	Washington	Sinclair Inlet
United States	Washington	Skagit Bay
United States	Washington	Snohomish Bay
United States	Washington	Toppenish Creek/Yakima River Oxbows
United States	Washington	Totten Inlet
United States	Washington	Trout Lake Marsh
United States	Washington	Umatilla
United States	Washington	Vancouver Lake
United States	Washington	Willapa Bay
United States	Washington	Wynoochee River Valley

A3

Appendix 3: Potential co-funders for each site

Bahía Santa María

NMBCA, NAWCA, CONANP, CONAFOR, USFWS, Mitsubishi Foundation

Panama Bay

NMBCA, USFWS, Wildlife without Borders program (US Dept. of State), government of Panama

Chiloe Island

NMBCA, USFWS, Wildlife without Borders program (US Dept. of State), government of Chile

Central Valley Complex

California state bonds, NAWCA, foundations (Bechtel, Annenberg, Hewlett), USFWS, Central Valley Joint Venture

Grays Harbor

National Coastal Wetlands Conservation grants, USFWS, NAWCA, Pacific Coast Joint Venture, WDFW, WSDA

A4

Appendix 4: ROI analysis

The ROI analysis ranked packages of interventions at each of the 16 sites in the "string of pearls" by comparing the potential shorebird benefit, the probability of the intervention succeeding, and a rough cost estimate for the intervention (Figure 13).

Preliminary filter

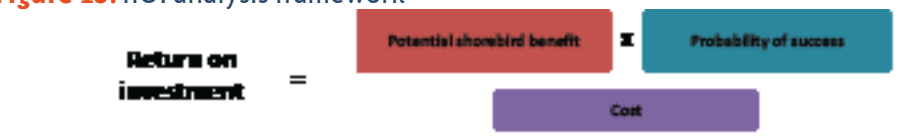
Prior to the ROI analysis, the string of pearls sites were selected from a list of over 200 sites used by Pacific coast-dependent shorebirds (see Appendix 2). In North America, sites with peak counts of 100,000 shorebirds were selected; in Central and South America the threshold was 50,000. The threshold for qualification was set lower in Central and South America because fewer species of North American shorebirds migrate so far south. This initial filter identified 16 critical "pearl" sites.

ROI analysis

Potential shorebird benefit

The potential shorebird benefit is based on the habitat improvement from intervening at the site, the peak # of shorebirds using the site, and the number of species for which the site is a major site (Figure 13).

Figure 13. ROI analysis framework



Potential shorebird benefit	Probability of success	Cost
Threat reduction X Peak # of shorebirds at site X Species diversity score	Current capacity X Sea level rise risk	Activity-specific score
Threat reduction Decrease in threat score from intervention (purchase/easement, restoration, water mgmt., or invasive plant removal) Peak # of shorebirds at site Total # of shorebirds Species diversity score # species for which site is major / max # at all sites	Current capacity: Groups working at site Sea level rise risk: Long-term threat scenarios	Activity-specific score: Particular score for each of the 4 activities, adjusted by country and US zone

Habitat improvement/Threat reduction

Each site was assigned a subjective threat score of 0-3 in 8 categories (see table below). All categories were weighted equally, so that the maximum possible score for a site was 24.

List of threat categories
Water pollution
Water flow alteration
Conversion to non-wetland
Urban/industrial development
Recreational disturbance
Introduced plants
Introduced predators and invertebrates
Aquaculture

Each type of intervention was assumed to address specific threats (see table below). For these categories, the interventions were assumed to reduce the threat to 0. Threat reduction was equal to the site's total threat score before the intervention minus the total threat score after the intervention.

Intervention type	Threats addressed
Land purchase/ easement	Urban/industrial development Recreational disturbance Aquaculture
Habitat restoration	Water flow alteration Conversion to non-wetland Introduced plants Aquaculture
Water management	Water pollution Water flow alteration

Peak number of shorebirds at the site

The peak number of shorebirds at the site was taken from databases provided by WHSRN and PRBO, as well as other sources.

Species diversity index

Species diversity was measured by the number of species for which peak counts at the site equal at least 2% of the estimated global population. This value was converted to an index by dividing the number of species at the site by the number of species at the most diverse site (18 species, at the Copper River Delta). Estimated total populations were taken from the US Shorebird Conservation Plan.

Probability of success

Probability of success (POS) was the product of a capacity risk factor and a long-term sea-level rise risk factor (Figure 13).

Current conservation capacity

Capacity was assessed based on the number of organizations and agencies active at each site. Subjective weighting scores of 1-4 were assigned to each organization based on its level of engagement at the site and on its size, personnel, and history. POS values for this factor ranged from 70%-95%.

Sea-level rise risk

Sea-level rise risk was calculated based on the percentage of intertidal habitats at a site expected to be lost to sea-level rise in 2100, given mid-range sea-level rise projections. In some cases where no data or only low-quality data were available, this value was adjusted subjectively. POS values for this factor ranged from 70%-100% (the 100% was for the Central Valley of California, which is located inland).

Cost

Costs were estimated roughly by applying geographically-adjusted per-hectare costs to each intervention at each site. For sites smaller than 5000 hectares, the actual size was used to estimate cost. For sites larger than 5000 Ha, 5000 Ha was used as the size, given that in most cases shorebirds tend to be, or could be, concentrated in smaller areas within these larger sites.

Land purchase/easement

In the US, costs for land purchase were based on reported costs for land purchase and easement in different states under federal coastal grant programs, including NAWCA and National Coastal Wetlands Conservation grants. Because data were unavailable for Latin America sites, costs were set to be slightly lower than costs in the Pacific Northwest, which was the least expensive of Pacific regions. This is likely an overestimate in most Latin American countries.

Habitat restoration

Restoration costs were based on an estimate provided in the Central California Joint Venture implementation plan. These costs were adjusted downward for the Pacific Northwest in accordance with expert estimates (from interviews). Latin America costs were set equal to Pacific Northwest costs. Again, this is possibly an overestimate for Latin America.

Water management

Water management costs for California and the Pacific Northwest were based on expert opinions from interviews. Again, Latin America costs were set equal to Pacific Northwest costs, which is probably an overestimate.

Geographically-adjusted cost estimates ($000 per hectare)			
Region	**Purchase/easement**	**Restoration**	**Water**
California	14.4	7.5	3.7
Oregon	4.3	5.0	2.5
Washington	4.3	5.0	2.5
Alaska	1.5	5.0	2.5
Mexico	3.5	5.0	2.5
Panama	3.5	5.0	2.5
Colombia	3.5	5.0	2.5
Ecuador	3.5	5.0	2.5
Peru	3.5	5.0	2.5
Chile	3.5	5.0	2.5

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