Key conservation goals for the San Quintín region and their linkage to properties and landscapes of the region.

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Introduction

The San Quintín region of Baja California has been a key conservation priority for many scientists, activists and organizations for decades. It is not only the best preserved large wetland in the Southern California Bight and the California Floristic Province (ie, between Point Conception, California and northwest Baja California) and an important wintering area of brant geese and shorebirds; it is also home to many local endemic species (plants, reptiles, and mammals, although a number of the endemic mammals may already be extinct). The adjacent valley and uplands are the most productive agricultural region in northwest Baja California, and the bay hosts successful and environmentally sustainable oyster farms, and is the home of the largest artisanal and sport fishery south of Ensenda.

The goal of this paper is to discuss some of the conservation sites and strategies for the region, and to compare various areas in regard to their ability to contribute to identified conservation goals.

The paper is arranged by taxonomic group for convenience of discussion, although sometimes functional groups (like brant and eelgrass) will be discussed together. A summary discusses conservation priorities by area.

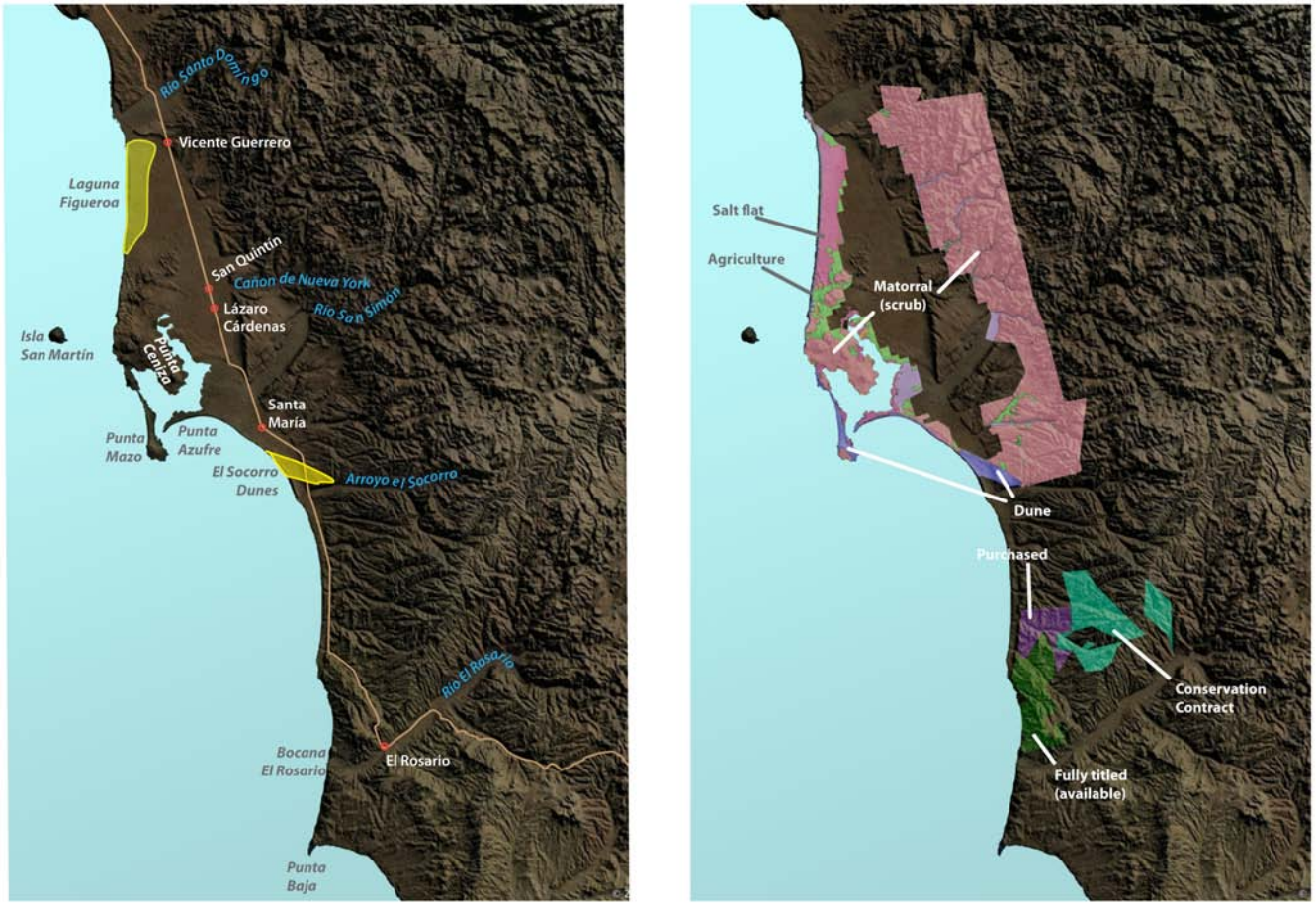

Figure 1. Map of San Quintín to El Rosario region. Left: selected geographic features and population centers. Right: selected habitats in proposed San Quintín Natural Protected Area, and selected parcels identified by Terra Peninsular in Ejido Reforma Agrária Integral, in the El Rosario conservation corridor.

Background

San Quintín has been recognized as an priority conservation area because of its endemic species; its connections to the Pacific Flyway and as the southern anchor of the California Floristic Province.

The San Quintín plain had some of the most dense prehistoric human populations known from Baja California (Moore 1999; Moore 2001a; Figueroa Beltán, 2009). Archaeological studies suggest that the bay was not an important source of food until after 3,000 years before present, which suggests that the bay was not fully formed as an intertidal resource before that time (Moore 2004). This may be due to idiosyncrasies of the development of the bay, or, as suggested by Moore, that, until that time, sea levels did not reach the level of the lava flows that form the bottom of many of the wetlands.

The area has been the site of various development schemes for over 150 years. In 1867 the town of San Simón was described as:

> approaching the place, our eyes were gladdened by the sight of two or three very American-looking board houses and a well-clear piece of road, broad and smooth as a racetrack…. Without knowing it, we had stumbled on an embryo American town (William More Gabb, quoted in Goldbaum 1971).

This early incarnation was what remained from a scheme to offer a land route from Colorado to California, before the railroads were built.

At the end of the nineteenth century, the bay was the site of a large "English colony" that attempted to grow wheat on the San Quintín plain, and which appeared to have great economic prospects. The economic development of the town was tied to the ability to bring large vessels into the bay, where cargo could be unloaded:

> Bahía de San Quintín, next to the bay at Ensenada, offered the best natural port in northern Baja California, but the estuary, or inner bay, where the town was situated, was little more than a lagoon. Gabb remarked in 1867 that the bay was "so small and shallow that the little vessel of eight or ten tons, that comes here occasionally, has difficulty passing the bar…. Twenty years later a plan to dredge was afoot…, and no doubt carried out, for shortly afterward a pier was built near the town…. [B]y 1912, the only regular steamer then calling here had to remain nearly 5 miles from the town, handling cargo by means of lighters (Goldbaum 1971).

While the agricultural development of the valley started out with great fanfare (small lots sold for $1,000 in 1888, Orcutt 1921), it was ultimately unsuccessful and was abandoned. (There is a story that the locomotive of a railroad that was planned is buried in the sands at the entrance to the harbor, where it fell off a barge as the settlers were leaving). By 1919 San Quintín was a very small town indeed:

> My donkey was refused a drink of water at the gendarmerie by the young officer that seemed in command, but met with greater hospitality at the old Hanbury Hotel—a relic of boom days then owned by an American. The "city" was found to contain perhaps a score of dilapidated houses, wrecks of their former estate, windows and doors broken or missing, but occupied by a few thriftless Mexican families, with children attending a school. The

> population was said to consist of 27 people, 26 of whom were officials—but this failed to take into account the women and children and the two Chinese store keepers—one of whom I found had one package of oatmeal—but as it was wormy I allowed it to stay on his shelves, where it perhaps still rests (Orcutt 1921).

Orcutt visited San Quintín 1886, when he made the first collection of Shaw's Agave (*Agave shawii*) and the vernal pool species *Orcuttia californica* and *Eriogonum fastigiatum* (neither of which now occur in the area due to the destruction of the vernal pools). In 1910 A. R. Howell visited the area and remarked on the bird life of the region. He reported extraordinary numbers of cormorants:

> ...but not until we were well inside the bay did I see something which I have always longed to observe. A sandy tide island was black with cormorants, but it was too far away to determine the species. There were acres of them, scores of thousands, and after we had passed they began to leave in a long black ribbon, never varying in thickness or width, and continuing for more than an hour, by which time we had passed out of sight (Howell 1911).

This colony bred on Isla San Martín until the 1960s, at which time it disappeared, perhaps due to human disturbance (Palacios & Mellink 2000).

San Quintín did not begin to develop as a population center until the introduction of irrigated agriculture and sufficient infrastructure to bring fresh produce to the markets of the United States. Development of irrigated agriculture started in the 1950s (Aguirre-Muñoz et al 2001), and by 2010 the population of the valley had grown to at least 55,000 inhabitants (Coalición para la protección de San Quintín 2011).

Efforts to protect Bahía San Quintín date back to at least 1995, when *pro esteros* attempted to purchase Punta Mazo from its presumed owner, Robert Yeaton. Since that time, a coalition of groups, including *pro esteros*, Terra Peninsular, Pronatura Noroeste, The Nature Conservancy and Conservation Biology Institute have worked to protect the bay and surrounding areas. In spite of repeated negotiations, no land purchases have been consummated. In 2009, Terra Peninsular was able to obtain concessions for the ZOFEMAT (Zona Federal Marítimo, a 20 m wide strip at the mean high tide line) around many of the wetlands of the bay, which control access for development. (And, recently, a regulatory decision has confirmed that no fees are due the Mexican government to maintain this control). *Pro esteros* has been using a "pride campaign" based on a model developed by the organization RARE to create social understanding of the need for conservation. Recently the coalition has developed a proposal to declare a natural protected area (ANP) on the bay and the foothills of the valley, and efforts are being made to have the ANP declared this year (Coalición para la protección de San Quintín 2011).

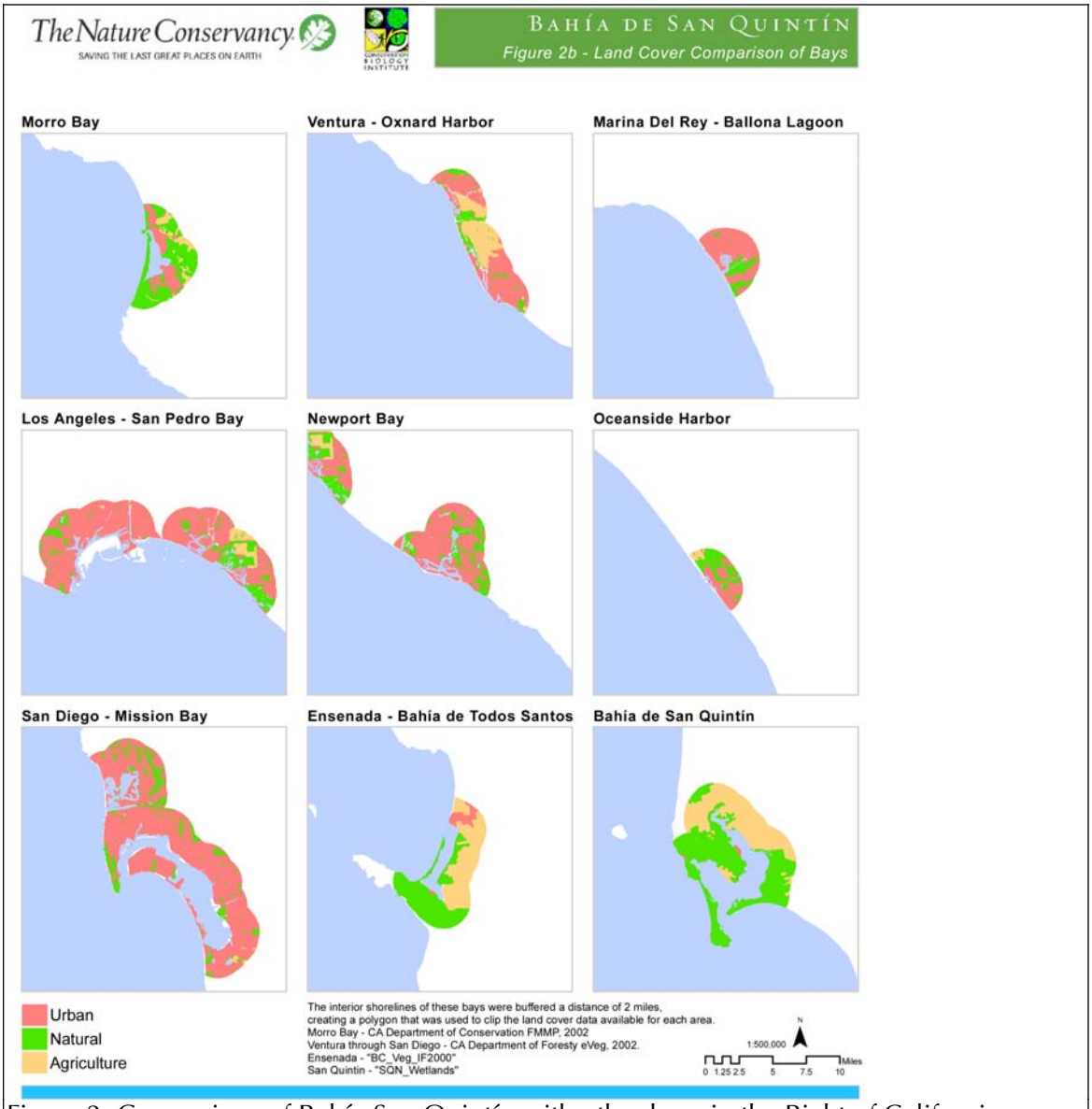

Figure 2. Comparison of Bahía San Quintín with other bays in the Bight of California showing the large areas of undisturbed habitat at San Quintín (TNC & CBI 2007a, Fig 2B).

Plants & Vegetation

There are two recent papers that give us some idea of the floristics of the region (Vanderplank, 2010a; Harper et al 2011). These papers use rather different methodologies. Vanderplank (2010b) is an intensive analysis of the flora of San Quintín west of Highway 1, south of Río Santo Domingo and north of Arroyo El Socorro (basically all the land of greater San Quintín west of the highway). This study included Isla San Martín, a volcanic island offshore about 1 km in diameter, which is already part of a protected area.

The study of Harper et al. (2011) is less intensive, being a "quick and dirty" analysis of conservation priorities in Colonet, where the Mexican government proposed to build an international port (which plans are now cancelled). Many of the vernal pool species that formerly occurred at San Quintín are still found at Colonet.

The coastal plain between Colonet and San Quintín is mostly in agriculture, and little native habitat remains between them. A third study can be used for comparison is a flora of Punta Banda (Mulroy et al 1979), near Ensenada, a smaller area which is still surprisingly intact.

Unfortunately, there is much less information available on the plants of the El Rosario region. Field studies are under way, which will give us a better outline of the the important areas for conservation. The El Rosario region forms a corridor, connecting the proposed San Quintín protected areas and the extensive protected areas "Valle de los Cirios" and "El Vizcaíno."

Plant species

The San Quintín region has 351 native plant taxa. In comparison, the Colonet study recorded 383 native taxa in an area twice as large, and 208 were found at Punta Banda. There is only one native tree species in San Quintín (*Aesculus parryi*).

Some of the narrowly endemic plant species (ie, those that occur only in this area) of San Quintín are identified by Vanderplank:

Taxon	Notes
Amsinckia inepta (Boraginaceae)	Possibly endemic to the volcanic fields of San Quintín
Astragalus anemophilus (Fabaceae)	Only one specimen known outside of the dunes of greater San Quintín
Chenopodium flabellifolium (Chenopodiaceae)	Known from Isla San Martín only
Chorizanthe chaetophora & C. inequalis (Polygonaceae)	N-S range of < 120 km, and three other species in this genus found in SQ are endemic to the peninsula.
Cryptantha pondii (Boraginaceae)	Extremely rare and not well-studied
Dudleya anthonyi (Crassulaceae)	Common in volcanic fields on the coast and Isla San Martín, and found nowhere else.
Leptosiphon laxus (Polemoniaceae)	Rare in San Quintín, found mostly in land directly to the east of the highway.
Oenothera wigginsii (Onagraceae)	Known, with the exception of one specimen, only from San Quintín.
Solanum palmeri (Solanaceae)	Known only from San Quintín, Isla San Martín, and Isla Todos Santos near Ensenada.

San Quintín was an area with extensive vernal pools and wetland habitats along the arroyos and rivers, and with a large seasonal wetland (known as Laguna Mormona or Laguna Figueroa) at the mouth of the Río Santo Domingo. Vanderplank documents that at least 24 plant taxa occurred in wetland habitats in the San Quintín region but can no longer be found there, due to habitat alteration. In addition, there was probably another locally endemic vernal pool species in the genus *Eryngium* that is now extinct, although that species has not been formally described. *Dithyrea maritima* (Brassicaceae) is a globally endangered species that occurs on Punta Mazo (Vanderplank, 2010b).

Besides the putative *Eryngium* species, all the extirpated vernal pool taxa of the San Quintín plain exist elsewhere, and the topography of the vernal pools has not yet been destroyed. Conceivably, vernal pool habitats could be restored, or constructed *de novo*, but only with much effort and cost.

Vegetation

Vanderplank identifies the following vegetation types as the most important for conservation in the San Quintín region:[1]

Vegetation type	N taxa[1]	Notes
Maritime succulent scrub	188/36	A common vegetation of the region, but here modified by volcanic soil, which supports the local endemic *Dudleya anthonii* as well as many other endemic and rare taxa.
Dunes	89/24	The dunes of Punta Mazo are active (unstabilized), while those of El Socorro are mostly stabilized and support a distinct flora. Compared to dune systems north of the border, these are in quite good shape and are not being used by off-road enthusiasts.
Saltmarsh	28/0	San Quintín has extensive pristine saltmarsh habitats. While they do not support an endemic flora, they are critically important conservation goals for fish, birds and intertidal organisms. Saline flats and hummocks within the marshes support a variety of plants, including the poorly known, locally endemic cactus *Mammillaria louisae*.
Riparian	83/17	There are three major riparian corridors in the region, from N to S: Río Santo Domingo, Río San Simón, and Arroyo El Socorro. While all are highly altered and have many non-native species, each has a unique assortment of native plants. Flooding in 2010 showed the importance of maintaining these riparian corridors intact.
Middens	95/47	San Quintín was an area with extraordinarily high numbers of Native Americans until the 18th century, and the shell middens form an extensive and unique habitat. Vanderplank studied the flora from the middens and showed it to be quite distinct, with its own set of species, and the highest number of endemic plant species of any habitat in the region.
Vernal pool	100/22	Only remnant habitat is known, and then only in wet years. When vernal pool habitat is formed, it is unique in having no non-native plant species and a high level of diversity even after the local extirpation of many species that were adapted to this environment.

It is remarkable that middens, a localized vegetation type based on soil formation created by human settlement, has the largest number of endemic species. Vanderplank identifies middens as an important priority for plant conservation in the San Quintín region.

1. "N taxa" is the number of native plant taxa found/number of taxa endemic to north-west Baja California

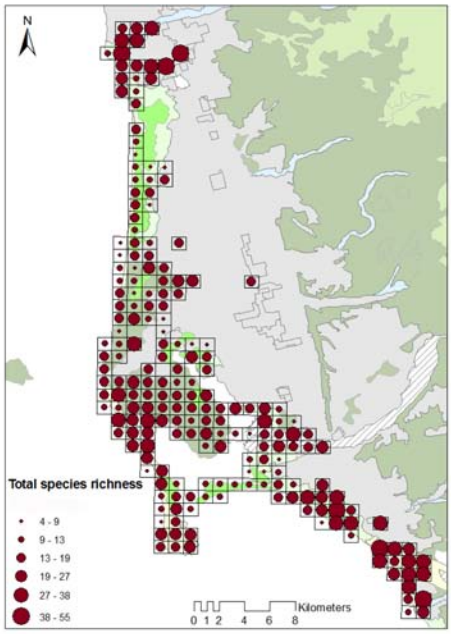

Fig. 13: Total species richness by km square for perennial vegetation of Greater San Quintín. As indicated at lower left, the size of the circle reflects number of species recorded per square.

Figure 3. Plant species richness in San Quintín region (Vanderplank, 2010b, Fig. 13).

Conservation recommendations

Vanderplank recorded species lists of native perennials for each of 206 1 km × 1 km squares in the region in order to determine conservation priority areas. Her recommendations (highly edited) are:

> Three primary regions of high species richness emerge—at the northern and southern extremes of the study area, and along the coast adjacent to the volcanic field. The northern region of high species richness has two distinct subareas: Santo Domingo Wash (northern boundary of the study area) and a clay mesa (slightly southeast from the wash)…. Both [of these areas] have significantly more non-native species ["weeds"] than typical of the study area as a whole.
>
> The coastal strip near the volcanic field that includes the tip of the peninsula at Monte Mazo, and Monte Sudoeste, is particularly diverse. This area includes a complex patchwork of habitats along the coast which likely contributes to high species richness…, [and] the coastal strip is always rich in native, rare and endemic species [and is relatively intact]. Monte Mazo, at the tip of the sand spit, does not harbor a significantly high number of endemic plants, but does have significantly high numbers of rare and native taxa.

…

> Near the southern end of the study area, the El Socorro Dunes stand out as the largest area of high species richness, and perhaps the most in need of conservation…. Although there are some differences in the pattern of km squares that harbor significantly high numbers of native, endemic and rare taxa, the general area is rich in all of these.
>
> …
>
> Thirty-four percent of the species that comprise the flora of Greater San Quintín are rare and/or locally endemic. Greater San Quintín is also home to several taxa that do not occur far outside the study area. These taxa should be of the greatest concern for conservation. The San Quintín Volcanic Field, a unique geological formation in Mexico, is home to the majority of these taxa.
>
> The unusual mix of plants with provenance from the desert area to the south, and the CFP to the north makes Greater San Quintín a floristically rich area. The high percentage of endemic taxa makes Greater San Quintín a priority for conservation. The habitat quality of the scrub, marshes and dunes should be preserved to the greatest extent possible and further anthropogenic disturbance of riparian areas should be avoided.

Plants and vegetation outside of "greater San Quintín"

Much less is known of the flora east of the highway or south of El Socorro.

There are very interesting clay lenses on the road to "Nueva York" where *Acanthomintha ilicifolia* can be found. There is some of the most extensive coastal succulent scrub and chaparral found in the foothills of the Sierra San Pedro Mártir. These habitats are very common in Baja California, but the extent and continuity of the habitat is truly remarkable. The extremely local Composite *Hazardia enormidens* is found in this region (known from two locations: San Isidoro, 30°44'N, 115°34'W and another location "40 km SSE"; Clark 1979).

It is impossible to compare the El Rosario corridor to San Quintín in terms of plant conservation. It appears that there are fewer local endemics in this region than in San Quintín, but it is impossible to make a clear comparison without equal collection effort. The locally endemic composite *Hazardia rosarica* is found up to 20 km inland from the coast with a north-south range of about 50 km from El Socorro south to 7 miles NNW of El Rosario (Clark 1979).

It seems likely that all the habitats to the east of San Quintín and south of El Socorro (possibly with the exception of the clay lenses mentioned above) and most of the species (with the exception of the local endemics *Hazardia rosarica* and *Hazardia enormidens*) are well represented elsewhere in Baja California.

Another criterion one could use to compare the regions is the intactness and continuity of habitat. While there are no data that can be used to make quantitative comparisons, is quite clear when visiting that the habitats of San Quintin, with the exception of El Socorro, are quite disturbed and weedy, while the areas at El Rosario are exceptional examples of continuous, intact coastal succulent scrub, which are now quite rare in coastal north-west Baja California.

Avifauna

San Quintín Bay has 110 species of birds (García-Gutiérrez et al 2010, see also pro esteros ND). I haven't found a recent list of upland birds, but there is no reason to think that San Quintín is either a particularly important or unimportant area for breeding and wintering birds compared to similar coastal areas of Baja California.

Some of the focal species that one might include in a conservation plan include:

Pacific Black Brant (*Branta bernicla nigricans*)

The Pacific Black Brant nest in in the Yukon-Kuskokwim Delta and migrate to the Pacific coast of Mexico in the winter (Stehn et al 2011). By all accounts, San Quintín is the most important bay for wintering populations of this subspecies of brant. Twenty percent of this subspecies winter in San Quintín, but probably a much higher proportion of the brant population rely on the resources of the bay as they pass through during fall and spring migration (TNC & CBI 2007a). Although historical counts were much higher, in recent decades total Brant population has been stable at about 150,000 individuals.

Brant may be a sentinel species for global warming effects. Their nesting areas have been moving northward in recent years (Ward et al 2005), and a growing sub-population now appears to be non-migratory, spending the entire year in Alaska (Mason et al 2006; Ward et al 2009).

Brant forage almost exclusively on eelgrass (*Zostera marina*), and the eelgrass abundance in Bahía San Quintín is probably the critical issue in maintaining the migratory brant population (Moore et al 2004). Eelgrass populations on the Pacific coast of Mexico south of San Quintín and in the Gulf of California appear to be sensitive to global warming effects, and may be declining (Santamaría-Gallegos et al 2003; Torre-Cosío et al 2003) and also being replaced by grasses that do not support brant (Lopez-Calderon et al 2010). Eelgrass abundance declines in warm El Niño years (Echavarria-Heras et al 2006), which increases the importance of San Quintín to brant in these years.

Another issue of concern is hunting of brant (Kramer et al 1979; Ward et al 1994; Riddingtion et al 1996). I don't know of any recent studies of the effects of hunting on brant in San Quintín, but presumably if the area is designated as a Natural Protected Area there will be additional studies and regulation of both legal and illegal hunting (García-Gutiérrez et al 2010).

Both arms of San Quintín Bay have extensive populations of eelgrass. A recent study of eelgrass (Ward et al 2003) showed the following:

- Eelgrass distribution in San Quintín Bay has been changing from a more continuous to a more patchy distribution.
- The largest threat identified for eelgrass populations was silting of the bay due to run-off from disturbed (agricultural) lands upstream, especially during El Niño winters.
- There was no detectable effect of oyster farming on eelgrass beds at San Quintín Bay.

Studies from other sites show that sea-grass populations have declined due to human disturbance for the following reasons (Hemminga & Duarte 2000):

- Eutrophication. This is probably the biggest threat to seagrass populations world-wide. It is presumably not as great of a threat to San Quintín bay because of the immense tidal flushing that occurs twice a day and the rare fresh water inputs—with their concomitant loads of fertilizers and pesticides (Aguirre-Muñoz et al 2001).

- Siltation. Use by large boats can stir up sand and mud in the water column and lead to death of sea-grasses. There is no evidence that the current use by small outboard launches (pangas) is having any effect. Due to waves, shifting sands, shallow drafts and absence of dredging, larger boats cannot readily enter or leave the bay.
- Alteration of the hydrology. Any change to hydrology, and especially alteration of the bottom of a bay can have major effects on the distribution of sea grasses (Hemminga & Duarte 2000). Although it is speculative, one suspects that dredging of the harbor mouth is the gravest threat to the sea-grass population, and therefore the winter brant population. Maintaining the hydrological integrity of the bay, and not allowing dredging for recreational or commercial purposes, is a key conservation goal.

Light-footed Clapper Rail (*Rallus longirostris levipes*)

This endangered sub-species is known from wetlands on the Pacific coast of southern California and northern Baja California. Historically, San Quintín was considered the most important site for light-footed clapper rails, having a larger population (about 500 pairs) than the entire state of California (Zembal & Massey 1981; Massey & Palacios 1994). The estimate of the light-footed clapper rail population in the US in 2010 is 441 pairs, from a recent low of 234 pairs in 2008 (Zembal et al 2011).

A recent study reports that the population in San Quintín is rapidly declining, by 56% from 2003 to 2008 (González Bernal, 2009). The census technique used in this study does not give comparable numbers to those measured earlier from the bay, or the latest counts from the United States. The current estimated population in San Quintín Bay is 661 (range 443-974) individuals in 2008. Reasons for this decline are probably "grazing [in the wetlands], opening of roads, human disturbance, feral animals, intrusion of agriculture into the wetlands, and construction of infrastructure for aquaculture activities" (González Bernal, 2009).

The critical habitat for the clapper rail is the tidal marsh. Currently most of the marshes are not threatened, and are protected by "ZOFEMAT" concessions obtained by Terra Peninsular. These concessions can be transferred to CONANP in the event that the bay is designated a Natural Protected Area. (They can even be transferred now, given the bay's registration as a Ramsar site). Joint protection through the ZOFEMAT and a protected area would presumably give the wetlands the highest level of protection allowed by Mexican law. However, it is unlikely that some threats to the clapper rail such as human disturbance and feral animals can be controlled by on-the-ground management, the best way to avoid disturbance of the avifauna of the marshes is to limit development in adjacent upland areas. (Limiting development in land adjacent to wetlands is also an important strategy to allow future adaptation to changes in sea level).

Other wading birds

San Quintín Bay supports about 25,000 wintering shorebirds (Page et al 1997; TNC & CBI 2007b), for which it was designated a WHSRN[2] site, making it the second most important wetland on the peninsula for wintering shorebirds (Ojo de Liebre has up to 10 x as many birds, and Laguna San Ignacio has comparable but slightly lower numbers on average).

Black rail (*Laterallus jamaicensis*) is a very poorly known and rare wetland bird, that has been seen in San Quintín after a long absence (Erickson et al 1992; Hamilton et al 2002). Black skimmers

2. Western Hemisphere Shorebird Reserve Network

now occur in the bay (Kramer 1983; Palacios & Alfaro 1992) with winter counts of over 400 individuals (Hamilton et al 2004).

Snowy plover (*Charadrius nivosus*) is a highly threatened wading bird of North America. Laguna Figueroa (aka Laguna Mormona) is an important wintering area with counts of over 300 individuals (Erickson et al 2003) and the barrier beaches and playas of San Quintín and Laguna Figueroa are important breeding areas for the species (Palacios & Alfaro 1991; Palacios et al 1994; Page et al 2009).

Other bird species

Burrowing owl (*Athene cuniculara*) is commonly seen in both native scrub and agricultural lands in San Quintín (Palacios et al 1999).

Least tern (*Sternula antillarum*) has a large breeding population at San Quintín bay, historically nearly 100 pairs (Massey & Palacios 1994). As elsewhere in North America, this species can continue to breed here only if disturbance (humans on foot, domestic and feral animals, and off-road vehicles) can be controlled (Zuria & Mellink 2002).

Mammals[3]

Much less is known about the conservation challenges for mammals in the region when compared to the avifauna. Many of the native and endemic mammals of the region are thought to be extinct, including

- *Dipodomys gravipes* (San Quintín Kangaroo Rat). This species was only discovered in 1925, and was common in the sparse vegetation of the San Quintín plain, especially near Misión Santo Domingo (Best & Lackey 1985; Patton & Álvarez-Castañeda 1999). The areas it was known from have been converted to intense agriculture. It has not been collected for over a decade, and is considered likely extinct (Ceballos et al 2002).
- *Dipodomys merriam quintinensis* (subspecies of Merriam's Kangaroo Rat). The authors of the most recent paper to treat this subspecies were not able to trap any animals, and its habitat, like that of *D. gravipes* is basically absent (Álvarez-Castañeda et al 2009). It is possibly extinct.
- *Microtus californicus aequivocatus* (subspecies of the California Vole). This subspecies occurred from Colonet to El Rosario, presumably in wet depressions and riparian areas. It, like all the endemic subspecies of *Microtus californicus* that occurred in Baja California, is probably extinct (Cudworth & Koprowski 2010).
- *Sorex ornatus juncensis* (subspecies of the Ornate Shrew). This subspecies was discovered by Edward Nelson during his transversal of the peninsula in 1907, and was considered extinct as long ago as the 1940s (Carraway 2007).
- *Antilocapra americana peninsularis* (Peninsular Pronghorn). Pronghorn historically occurred in the San Quintín valley, and possibly as far north as Colonet (Cancino & Ortega-Rubio 1994), but now are not found in Baja California.

3. The mammal taxa endemic to Isla San Martín, *Neotoma bryanti martinensis* (San Martín Woodrat, extinct), and *Peromyscus maniculatus exiguus* (San Martín White-footed Mouse) are not discussed here because the island is considered well-protected under Mexican law.

- *Enhydra lutris nereis* (Southern Sea Otter). The sea otter historically ranged as far south as Punta Eugenia. Animals have been sighted on Isla San Martín and other Pacific waters of Baja California in the twentieth century, but the species has not been known to reproduce here (Gallo-Reynoso & Rathbun 1997).

Recently the presence of the northern subspecies of the American Badger, *Taxidea taxus jeffersonii*, was confirmed in San Quintín (Ruiz-Campos et al 2002). It is suspected that this subspecies may be distributed along the coast from the border to possibly the southern limit of the state of Baja California.

No assessment of the conservation priorities for terrestrial mammals of the region has been made, but probably some of the important considerations are:

- Maintain habitat continuity and native habitat for rodents (*Peromyscus, Dipodomys*, *Neotoma*), rabbits and small predators (Coyote, Gray Fox, Bobcat);
- Limit hunting (legal and clandestine) to maintain current healthy populations of Mule Deer found in the El Rosario corridor (Peraza Perales, 2007).

The above two strategies are probably also the most important actions that can be taken to conserve the poorly understood puma population (*Puma concolor brownii*). Clandestine hunting is probably the biggest threat to pumas, but control of that is outside the scope of this document.

Aerial or satellite surveys should be made to determine whether there is any native habitat left in the now completely(?) agricultural San Quintín plain, and on-the-ground surveys made for the *Dipodomys, Microtus,* and *Sorex* species listed above. If any of these were found, that area would, of course, become a high-priority conservation goal.

Lizards and Snakes and Amphibians[4]

No up-to-date list of the herpetofauna of the region is available, and the available sources are missing many species known to occur in the region. It is beyond the scope of this report to create this list, but we can point out some of the threatened and listed species that are known to occur in the region and their conservation issues.

Arroyo Toad (*Anaxyrus californicus*). This Mexican and US-listed amphibian is known from the Río Santo Domingo and Río San Simón watersheds of the San Quintín plain (Gergus et al 2001; Mahrdt et al 2004; Lovich et al 2009).

Baja California Legless Lizard (*Anniella geronimensis*). This legless lizard is found only in a region of 87 km of coastline, centered on San Quintín Bay (Grismer 2002). It is specialized to live in fine sands, and is often found near the surface under bushes in El Socorro and Punta Mazo. It is common in the limited area in which it is found and is not considered endangered. It is also found on Islas San Martín and San Gerónimo (Lovich et al 2009).

Western Pond Turtle (*Actinemys marmorata*). The western pond turtle's southern limit in Baja California is Arroyo Grande in El Rosario (Grismer 2002). The Baja California populations are noticeably darker than southern California populations and form a distinct clade; there is some evidence that they should be described as an endemic species (Spinks et al 2009; Janzen et al 1997 cited in Grismer 2002).

4. The endemic lizards and snakes of Isla San Martín, *Elgaria multicarinata ignava* (Isla San Martín Alligator Lizard), *Hypsiglena ochrorhyncha martinensis* (Isla San Martín Nightsnake) and *Pituophis catenifer fulginatus* (Isla San Martín Gophersnake) are not considered here because the island is considered well-protected under Mexican law.

Sustainable economic uses

The major economic activity in San Quintín Bay is the cultivation of oysters (*Crassostrea gigas*). The beds of oysters fill the western arm of the bay (Bahía Falsa) and extend into the eastern arm, even though they are not authorized to do so. The value of the harvest was estimated at nearly US $2,000,000 in 1997 (Aguirre-Muñoz et al 2001), and it appears that the current density is near the carrying capacity of the bay (García Esquivel et al 2004). While it would seem that the large number of oyster beds should affect the habitat for native species, no effect has been detected on the distribution or abundance of eelgrass, on which the brant feed (Ward et al 2003).

San Quintín Bay is presumably an important nursery for the coastal fisheries of the region. By providing structure, the eelgrass beds, as well as probably the oyster beds, enhance the reproduction of these fish and contribute to the local fisheries (Heck et al 2003). The area off San Quintín Bay is the largest fin fishery on the Pacific coast of Baja California between Santo Tomás to Punta Canoas (Rosales-Casián & Gonzalez-Camacho 2003).

Other economic uses that rely on the natural values of the region include recreation, sport fishing (for yellowfin and rock fish), brant hunting and quail hunting.

Climate Change

Trying to estimate the effects of global climate change on the San Quintín region is impossible. All we can do here is to suggest some of the issues, some of the possible consequences of climate change, and what conservation goals might be in the short run to allow maximum flexibility in responding to these changes.

Climate

While models suggest a general rise in global surface temperatures of 2-4° C and a rise in global sea levels of perhaps 0.5–1.0 m by the end of this century (Solomon et al 2007; Cazenave & Llovel 2010a). These estimates are subject to a wide margin of error (depending on human behavior as well as uncertainties in the models), and to regional variation.

The effects of man-made global climate change in coastal Baja California may be quite specific to the region, and may diverge from those seen elsewhere. One of the most important determinants of the local climate is the pattern of upwelling of water in the California Current which creates many conditions that support the endemic species and communities of the region. The upwelling not only creates nutrient-rich waters that support the high productivity of the region, but the cool waters produced by upwelling determine the coastal environment and the coastal fogs that protect the land from extreme summer temperatures.

It is suggested that one of the major reasons that coastal northwest Baja California is center of plant diversity and endemism is that the coastal climate and the latitude have buffered the region from the extreme changes that took place in the Pleistocene (S. Vanderplank, pers. comm.) If this is so, it might be that the coastal environment will also buffer the region in the future. This could make coastal northwest Baja California a critical region for conservation.

While there are no clear predictions for the future climate of the region, measurements show that coastal temperatures in coastal southern California have been declining in recent decades (Lebassi et al 2009) and possibly upwelling intensities have been increasing (Demarcq 2009), which suggests that this region may continue to support the same plant and animal communities for the

foreseeable future. Another change that has been suspected, and for which there is some evidence, is an increase in El Niño/La Niña variation, with more extreme weather events becoming more common (Bograd et al 2009; Gergis & Fowler 2009; Gutiérrez-Ruacho et al 2010). If this is true, it emphasizes the need to create protected areas large enough to give local species the ability to maintain large enough populations, and to find refuges, to survive a series of unfavorable years.

Sea level rise

Many models suggest that global climate change will raise global sea levels from 0.5 to 1.0 m by the end of the century (Solomon et al 2007; Cazenave & Llovel 2010a), and, if anthropogenic factors are not controlled, sea levels will continue to increase at even higher rates of change in the 22nd century CE.

Since the Pleistocene sea level minimum, more than 100 m below modern sea level, sea levels have been rising at various rates, as estimated by studies around the world. Most studies show that sea levels rose at a rate of 12–15 mm/year until about 8,000 years before present (with possibly some sudden rises of more than 1 m when massive amounts of ice entered the sea), after which sea level rise slowed to about 2.5 mm/year, and slowed again to 0.5–1 mm/year about 4,000 years ago (Pirazzoli & Pluet 1991; Muhs et al 2004; Masters & Aiello 2007). However, some studies show that sea levels actually peaked 2–10 m above current levels between 2,000 and 8,000 years ago (Woodroffe & Horton 2005; NCDC 2008; Watcham et al 2011), and have declined to present values.

Current models suggest that sea level may rise by 0.5 to 1.0 m by the end of the century, and the rate of change at that time will be 5 to 15 mm/year (Cazenave & Llovel 2010b; Grinsted et al 2010), assuming that carbon emissions continue in line with projections.

The question is, what effects will sea level change have on the coastal geography of the San Quintín region, and what will be the conservation consequences? The dune and wetland systems of San Quintín, Laguna Figueroa and El Socorro are dynamic systems that are maintained by wind, waves, current and sediment flows, and it is to be expected that they will change in response to changes in sea level (and changes in winds, waves and sediment sources, if those occur). This means that any static analysis, that supposes that the land is held constant in the face of sea level change, is only a null model onto which various hypotheses can be layered.

The areas most vulnerable to sea level rise are those coastal areas with the lowest slope. The following figure gives one estimate of inundation of the land given a 2 m rise in sea level (i.e., some time in the 22nd century, under current models).

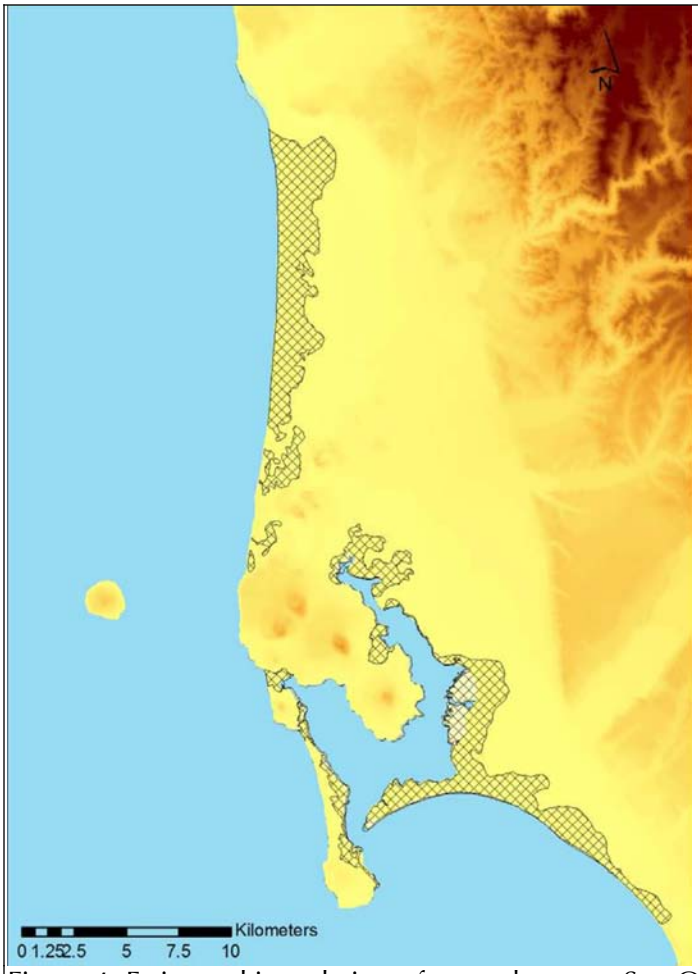

Figure 4. Estimated inundation of coastal greater San Quintín under a 2 m rise of global sea level (Vanderplank & Mata 2011, slide 30).

It can be seen that the areas that are most sensitive include the major wetlands on the eastern shore of the bay, the entire east-west beach at the southern entrance to the bay (Punta Azufre), the outer coast of El Socorro and the hypersaline playas to the north (Laguna Figueroa and adjacent areas).

However, studies elsewhere have demonstrated that dune formation processes are dynamic enough that they can build dunes even in the face of rising sea levels (Carter 1991; Saye & Pye 2007a; Walkden 2008a; Psuty & Silveira 2010). Perhaps the most relevant study is an analysis of coastal dune habitat in Wales, UK (Saye & Pye 2007b). Here the authors found that (p. 51):

> Based on the results of this study, no major net loss of dune habitat is predicted, although significant losses are likely to occur at some individual systems. There will be some loss of frontal dune area at such sites and there is likely to be an increase in dune sand mobility near the shore, leading to greater habitat diversity and dynamism.

Another study of the vulnerability of dune systems world-wide to sea level rise (Psuty & Silveira 2010) agrees that dunes are likely to move inland in the face of higher sea levels, but they can also

retain their general shape and move along-shore. This study and others (Carter 1991; Slott et al 2006; Walkden 2008b) emphasize two important issues for dune systems in the face of rising sea levels:

- Sources of sediment are crucial to dune maintenance. In the case of San Quintín, Río Santo Domingo (which flows into Laguna Figueroa) is probably the most important source of sediment for the dune fields of the bay and El Socorro. If that sediment source is blocked (for instance, by damming the river sufficiently to suppress floods), this may have at least as great an effect on the future of the bay and the dune systems as sea level rise.
- It is critical that dunes have places that they can move into. All the discussions of the future of dunes expect that the dune fields will change (and if wind and wave patterns change due to changes in storms and El Niño events, this is even more true).

The other question is what will happen to the wetlands of the region, including the wetlands in Bocana El Rosario. It is clear that the inundated areas of the bay will move into the upland. Depending on whether sediment continues to fill the bay, this could either increase the area of eelgrass (by increasing the bay size) or decrease it (by flooding the central part of the bay beyond the optimal depth for eelgrass). The current extensive wetlands, which support rails and shorebirds among other birds, will have to move inland or disappear. Again, this emphasizes the importance of forward-looking conservation measures to gain protection for (or, at least, limit human settlement in) the lands at the eastern and northern limits of the bay, where the greatest inland expansion of wetlands is expected. This is also true for the entire coastal area north of the bay (Laguna Figueroa), although in the high-energy wave environment here, it is more likely to convert to a barrier beach and lagoon system (perhaps like the entrance to La Misión, north of Ensenada).

Note that the loss of habitat for eelgrass in the last 20 years has been attributed to an increase of sediment inflow due to upstream erosion caused by agriculture (Ward et al 2003). This suggests that, at least in the short term, rising sea levels may increase the carrying capacity of the system for winter brant and marine organisms, like juvenile fish, that rely on the seagrass ecosystem.

Recommendations for conservation priorities

Given the discussion above, what are the most critical conservation actions that can be carried out to protect these resources? This paper will not attempt to rank various strategies, but will discuss some strategies in terms of the goals that each can accomplish.

Land purchase and contracts

Land purchase has been suggested, and in places implemented, in a number of different areas of the San Quintín/El Rosario corridor, including:

- Purchase of Punta Mazo (= Cabo San Quintín = Crola property)
- Purchase of parts of Punta Ceniza (the central peninsula in the bay)
- Purchase of Punta Azufre (the southern boundary of the bay)
- Purchase or contracts in the dunes of El Socorro
- Purchase and contracts in the El Rosario corridor, ie, that part of Ejido Reforma Agrária Integral that connects San Quintín, Valle de los Cirios Natural Protected Area, and the foothills of the Sierra San Pedro Mártir (and a possible protected area there)

What might these strategies accomplish in terms of the conservation of habitat and focal species of the region?

1. Control of Punta Mazo would achieve a number of critical goals. Punta Mazo has a strong population of the Baja California Legless Lizard and of *Dudleya anthonyi*, both local endemic species and also contains *Dithyrea maritima*, a globally endangered plant species. It hosts one of the most pristine coastal dune systems in the California Floristic Province, which is yet not trammeled by off-road vehicles or badly invaded by weeds. It is an iconic landscape of pre-settlement California—one of the few remaining on the coast in the California Floristic Province.

Legal analysis is required to determine if control of Punta Mazo would allow the land-holder to deter the channelization of the entrance to the harbor by dredging. Probably the greatest threat to eelgrass, brant, wetlands and fish nurseries is the alteration of the natural tidal cycles and topography of the bay. San Quintín has been proposed as both a passenger ship terminal and a recreational harbor in the past, and there is no reason to think that this threat has passed. (Legal analysis is also required to determine if the proposed Natural Protected Area for San Quintín will affect the ability of the government or private parties to dredge the harbor).

Perhaps the biggest short term and long term threat for the wetlands is human settlement on their periphery. Besides the disturbance that people will cause, their associated commensuals, such as domestic and feral dogs and cats, are a great threat to the light-footed clapper rail and other resident birds of the wetlands (González Bernal, 2009). Longer term, a key strategy is to have natural landscapes upland of current wetlands, to allow expansion under regimes of higher sea levels.

While current economic and social conditions seem to have temporarily minimized the threat of large-scale development on Punta Mazo, we cannot rely on this being true in the future. It seems unlikely that the threat of higher sea levels would deter development of the peninsula, as it will remain accessible by filling or bridging any seawater gap that develops at its northern end.

2. Control of Punta Ceniza achieves fewer conservation goals. There are not substantial populations of any endemic terrestrial species, and the major wetland is to the north of the current settlement (El Pedregal), and land around that wetland is not currently in negotiation by conservation buyers. There is no reason to think that control of part or most of Punta Ceniza would allow the owner to influence whether the bay is opened by dredging. Settlement does bring the threat of sewage and eutrophication—if settlement does occur, it will be important to tightly control septic flows into the bay.

3. Punta Azufre will presumably be flooded in the next century, unless beach deposition rates are able to keep up with changes in sea level. Probably it is not threatened by development, as the economic consequences of sea-level changes here are obvious to anyone. Regardless of whether Punta Azufre is lost in the next century, the wetlands to the north on the east side of the bay will probably continue to be important areas for fish and shorebirds. Currently these wetlands have been filling faster than sea level is rising, so the outlook is good that they will remain important habitat in the future.

Punta Azufre needs to be included in the legal analysis of the protection of the mouth of the bay. It is possible that ownership of the peninsula would help to eliminate the possibility of dredging of the entrance to the bay (José Luis Pérez Rocha, pers. comm.)

4. No analysis has yet been made of the potential of conservation purchases or contracts in the dunes of El Socorro. This area is being proposed for development by a local promoter, and one conservation buyer has purchased a parcel in the dunes (S. Vanderplank, pers. comm.) The dunes are rich with sensitive and endemic plant species, and have a large population of the endemic Baja California Legless Lizard. They are also a unique archeological resource documenting a large prehistoric (and historic) Native American population (Moore 2001b). The dunes are fed by the sands carried by the California Current and blown across the bay from Punta Mazo, so are presumably not threatened immediately by the effects of climate change. The possibility of purchases or conservation contracts in this dune field needs to be examined.

5. The lands of the El Rosario corridor show very different conservation values than those around the bay. These were the first large intact parcels in the California Floristic Province that Terra Peninsular identified as an iconic landscape. While less is known about the vegetation of these lands, it is clear that they are mostly native vegetation, with few weeds and an absence of grazing, in a region known to have the highest diversity scrub in the California Floristic province. The area has a diverse range of habitats and vegetation types. Protection of these lands will achieve one of Terra's long-term goals: the attainment of a protected corridor between Valle de los Cirios and San Quintín.

6. It is remarkable that no consideration has been made in the past to any purchases or land-conservation activities to the east of the highway in the San Quintín plain. If the proposed protected area is declared, it will encompass the interesting clay lenses known from the canyons of Nueva York. Whether the protected area will offer protection to these sites needs to be determined.

Studies (both herbarium and field) should be made of the distribution of three endemic plants from this region, *Hazardia rosarica, Hazardia enormidens* and *Leptosiphon laxus*, to determine their ranges and their conservation status, and the legal status of their range under the proposed protected San Quintín Natural Protected Area.

It is clear from the discussion above that the remaining wetlands of the San Quintín plain are critical to a number of reptiles and amphibians, including Western Pond Turtle and Arroyo Toad. Existing information on these species should be compiled and field trips to riparian areas made to determine if there are existing sites worth protecting. Similarly, an effort should be made to determine if the four "extinct" mammals, *Dipodomys gravipes*, *Dipodomys merriam quintinensis*, *Microtus californicus aequivocatus*, and *Sorex ornatus juncensis* still exist.

Botanists are actively searching for an remnant vernal pools and their associated plant species in the San Quintín plain, but none have been found.

Community engagement

Currently the NGO *pro esteros* has a full-time community and education specialist based in San Quintín. Efforts have been organized using a "pride campaign" with the brant as the emblematic species.

It is important that this campaign be extended to include habitats critical to other key species in the region. Regulation and practices in the waterways are a critical issue. Waterways are a threat the the bay because they bring agrochemicals and flooding to the shore. They are also important

because they contribute silt and sand to feed dunes and wetlands, and allow coastal formations to grow as sea levels rise.

The rivers and associated wetlands are habitat for turtles and toads, and the outfalls of the Arroyo Santo Domingo and Arroyo San Simón form extensive tidal flats which are important for shore birds, including Snowy and Mountain Plovers.

Science

It is obvious from this discussion that there continue to be many gaps in our knowledge of the conservation priorities of the region. Even though this report did not do a complete analysis of the "gray literature", it is striking that no reasonably complete, up-to-date species lists could be found for any of the vertebrate groups that are discussed here. No recent surveys have been made for remnant habitat (such as undeveloped parcels where endemic small mammals might survive), and there are no useful maps of the wetland habitats along the stream courses to give guidance for conservation priorities.

Much of this information resides in the heads of scientists who have worked in the region, but it is not available to set conservation priorities. This is probably the highest priority (and the least expensive) gap in the science: compilation of current knowledge of species occurrences and habitat geography, to be followed by targeted surveys to fill in our knowledge of the endemic and targeted species of the region.

Conclusions

This is a critical time for the future of greater San Quintín. There is great hope that the proposed Natural Protected Area will be declared soon. Conservation purchases have shown the potential for private land conservation mechanisms to achieve landscape-scale (tens of thousands of acres) protection in the El Rosario corridor. The wetlands are currently protected from development because Terra Peninsular has obtained the development rights to the land ("ZOFEMAT") that buffers them from upland habitats.

However, proposals have been made to make conservation purchases in San Quintín for nearly 2 decades now, with no success, and at least one major player in the region, The Nature Conservancy, has dramatically reduced its staffing and presence in the region.

It appears that a window is closing on the conservation of the San Quintín/El Rosario corridor, and any permanent protection, and any declarations of protected areas, will either happen soon, or not for quite some time.

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