Conservation Management Needs and Opportunities
Staten Island Ranch, San Joaquin County, California

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1. Introduction

This document was written to allow fuller consideration of the various management opportunities that are available at Staten Island. It does this by assembling disparate pieces of information that all have relevance for planning the future of the island. It describes the ecological significance of Staten Island, both from historical and present-day perspectives. It presents the situational context of the island, highlighting various factors that should be considered when planning for management of the property. Some of these factors are site-specific, while others are landscape-scale, and a function of the island being located in the Central Sacramento-San Joaquin River Delta, one of the most complex hydrographies in all of California.

As an agricultural property, Staten is intensively managed. Current management practices provide a multitude of benefits to a suite of important species. This document describes many of these practices, and the benefits they are thought to provide to wildlife. However, it also presents alternatives to current management, with discussion of the merits that they may convey.

Past and ongoing research that has been directed at better understanding how Sandhill Cranes and other species utilize habitats on the island and respond to different farm management practices is described. In closing, future research needs are discussed. If addressed, this research could improve not only the management of this property, but also other agricultural properties in the region.

Given the vast scope of this report, it does not provide exhaustive treatment of these topics, however, it should serve as a useful starting point for future discussions. It is important to have these discussions, as it is being increasing recognized that many of the current management practices in the Delta are unsustainable. At Staten, as on other farms in the region, there are incredible challenges, but there are also tremendous opportunities. Giving full consideration to the issues discussed in this report is a first step toward realizing those opportunities.

2. Ownership and Location

Staten Island is located within the Delta between the North and South Forks of the Mokelumne River, near Walnut Grove in San Joaquin County (Figure 1). The island is owned by The Nature Conservancy (TNC) and is considered part of the Cosumnes River Preserve. However, it is managed as a component of the Delta Project under the leadership of L. Winternitz. The island is currently operated by Conservation Farms and Ranches, Inc., a non-profit affiliate of TNC.

Staten Island is situated in the heart of the central Sacramento-San Joaquin River Delta region which is characterized by expanses of deep organic peat soils reclaimed from the marsh habitats that formerly typified the Delta. Peat soils were formed as tules and other plants were covered by sediment from the Sacramento and San Joaquin rivers throughout the years. These organic soils, up to 60 feet deep in some areas (Figure 2), were first farmed in the mid-1800s. Although highly productive for agriculture, peat is also very prone to subsidence. Similar to other reclaimed Delta islands, most areas of Staten Island lie below sea level (Soil Conservation Service 1993). LiDAR data collected in 2007 reveal surface elevations at Staten Island that range from sea level to nearly 16 feet (5 m) below sea level (Figure 3). Large perimeter levees along the North and South Forks of the Mokelumne River surround the island and provide protection from winter floods.

Figure 1. Map of Staten Island and surrounding roads, towns and waterways.

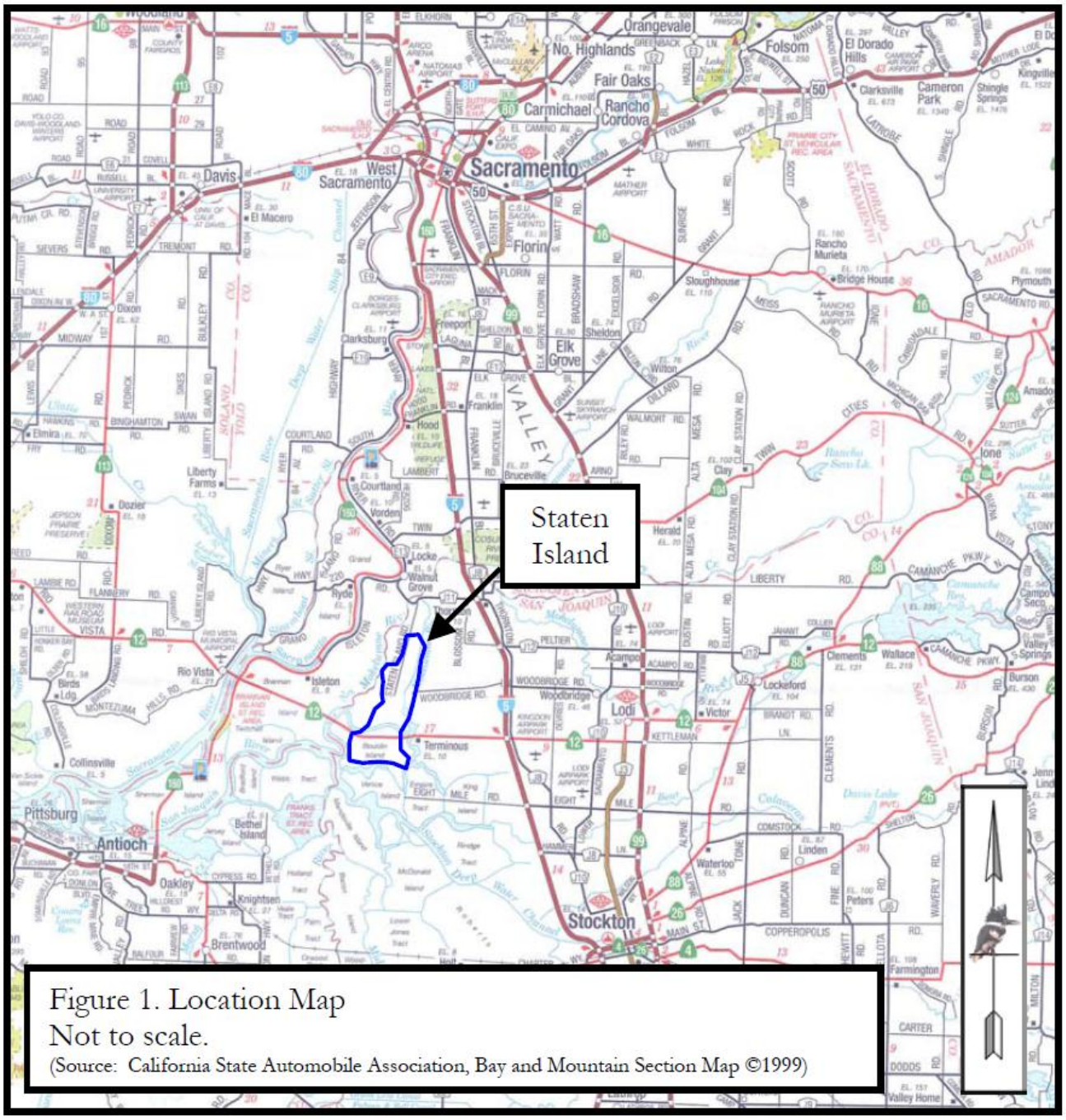


Figure 2. Thickness of organic soil, commonly referred to as peat, in the central Delta. Map from Deverel and Leighton 2010.

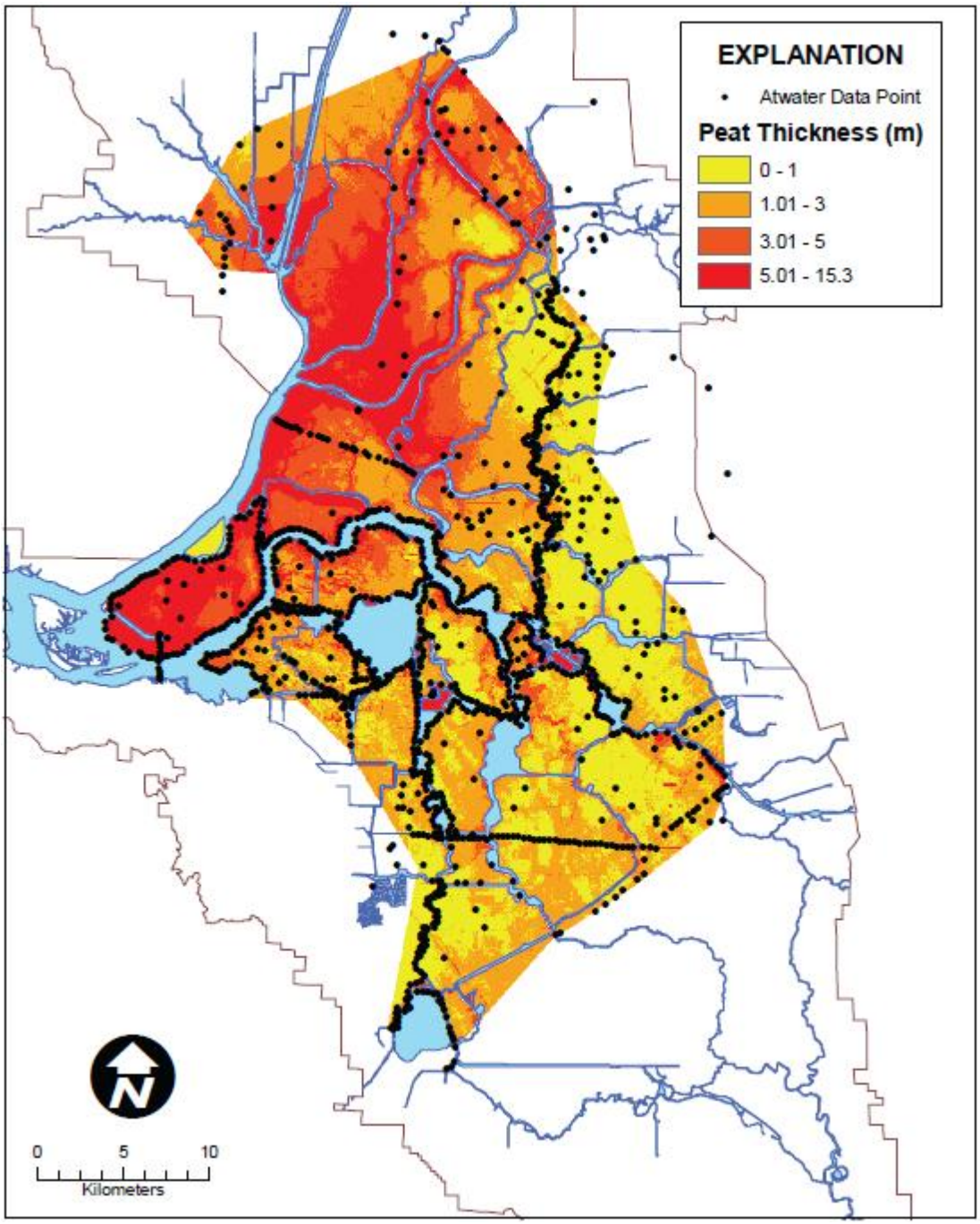
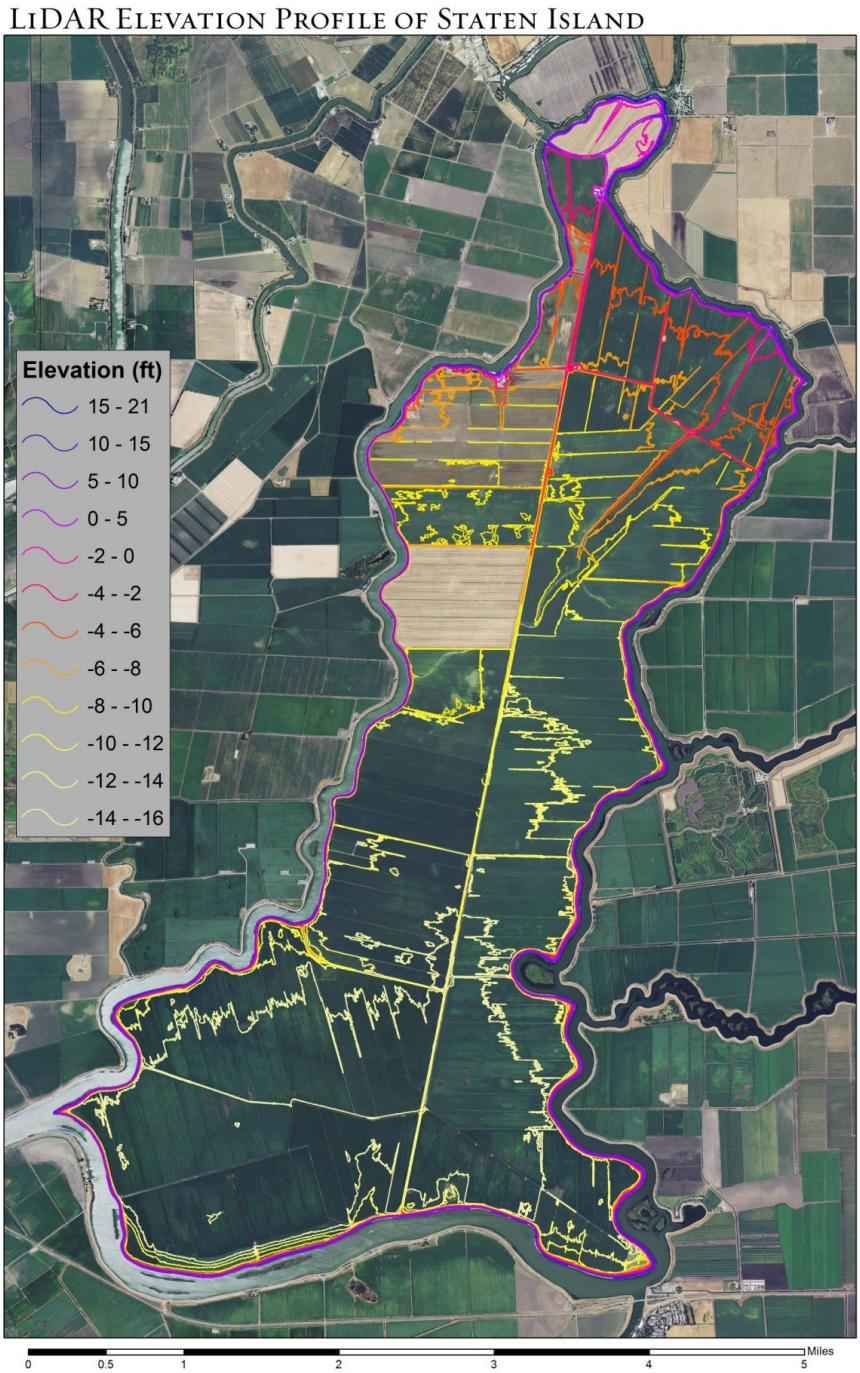


Figure 3. Surface elevation profiles of Staten Island. These data are from LiDAR flights of the Sacramento-San Joaquin Delta conducted during late January and February of 2007. The work was conducted under contract issued by California Department of Water Resources to URS Corporation. The prime LiDAR creation subcontractor was EarthData International (EDI, later Fugro EarthData). The principal aerial survey firm under subcontract to EDI was Airborne 1 Corporation. Airborne 1 performed the aerial survey, and EDI did the processing and deliverables preparation. Spectrum Mapping LLC conducted an independent QA/QC analysis of the products of the project.



3. Ecological Significance

Both currently and historically Staten Island has played an important role in supporting habitat for wildlife in the Delta region.

Prior to reclamation Staten Island likely supported expanses of permanent marsh, pockets of riparian scrub, and several meandering smaller sloughs. Soil survey data (Soil Conservation Service 1993) suggests that the southern 3/4^{ths} of Staten Island was dense permanent marsh with several small dead-end sloughs. The northern 1/4th of the island was probably a mosaic of permanent marsh and riparian scrub. Semi-permanent marsh was probably limited in this area and seasonal marsh was scarce. The island's habitats supported a diverse assemblage of resident wildlife and the open water areas of the marsh likely attracted migrating waterfowl in great numbers (Delta Protection Commission 1994).

Current day wetlands in the Delta are vastly reduced relative to the historical condition (Figure 4, Delta Protection Commission [1994]). Thus all remaining wetlands are of increased importance. In terms of acreage, seasonally flooded agriculture provides the vast majority of current day wetland habitat. At Staten Island, the expansion of grain crop acreage in the 1970s, coupled with the reduced disturbance that resulted from single-ownership farming and careful management of the hunting program, lead to substantial increases in crane and waterfowl use (Ivey et al. 2003). Prior to this time a large portion of the ranch was planted to sugar beets. Ever since farming was initiated at Staten in the late 1800s, the island was dedicated to small grains and vegetable crops. During 1970s and 1980s, cranes lost traditional roost and forage areas in the Delta due to land conversion to vineyards and orchards (Ivey et al. 2003). Because of the large numbers of sandhill cranes and waterfowl using the Staten Island, it was recognized as an important site by the Central Valley Habitat Joint Venture and Ducks Unlimited in the early 1990s.

Staten is currently one of the most important sites for sandhill cranes in all of California. It is of extreme importance for the greater Sandhill Crane subspecies (*Grus canadensis tabida*), which is state listed as Threatened (Ivey and Herziger 2003). Crane use at Staten has dramatically increased since the 1980s due to conversion to crops with greater wildlife value and a reduction in disturbance from changes in farming and hunting operations (Ivey and Herziger 2003). In addition to receiving high use by wintering sandhill cranes and waterfowl, Staten supports a wide variety of other wildlife throughout the year (see *Conservation Targets* section below).

4. Conservation Targets

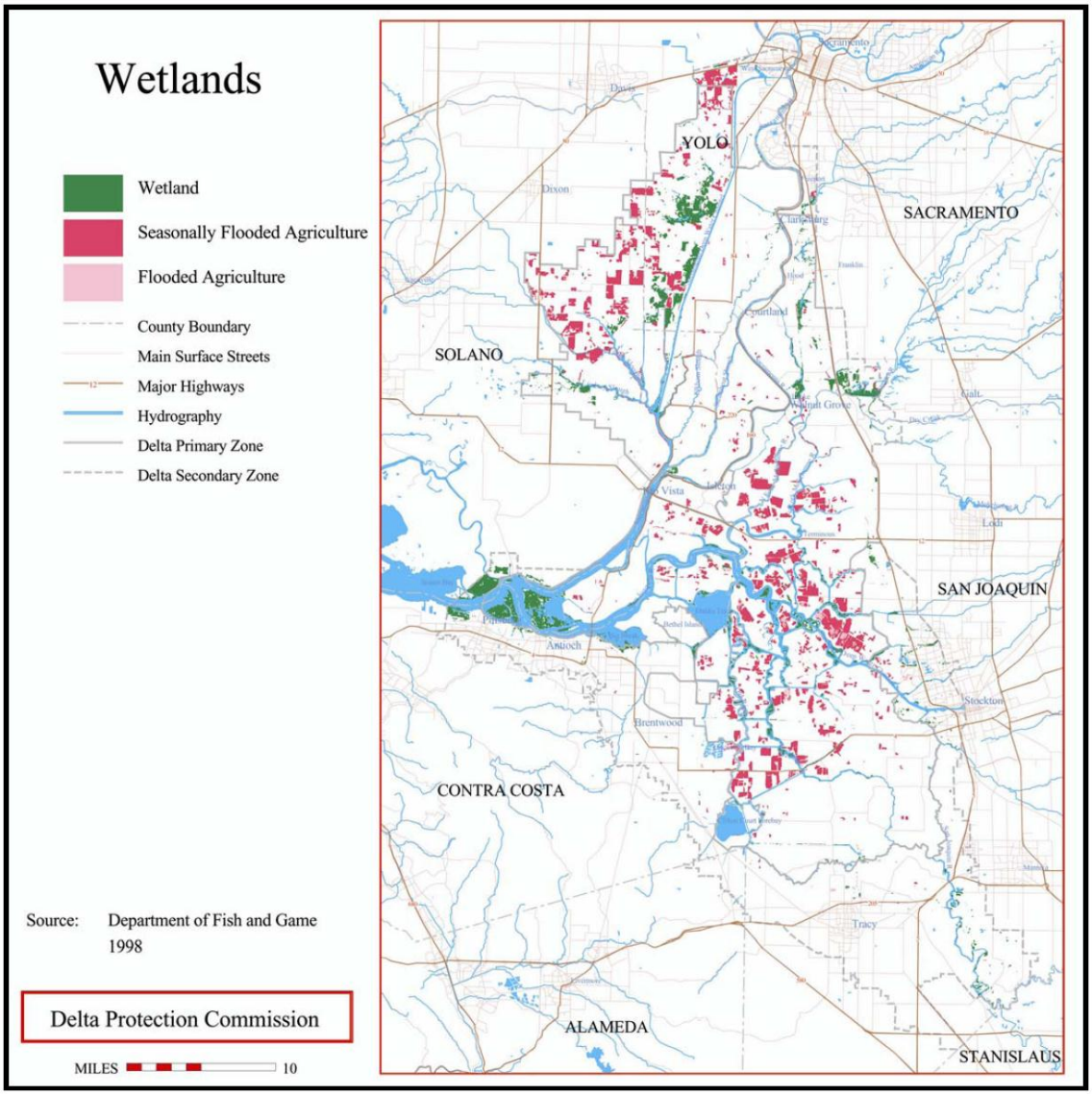
Staten Island provides important representation of a subset of the Conservation Targets indentified in the Sacramento-San Joaquin River Delta Conservation Action Plan (Delta CAP, TNC 2010). The Delta CAP identifies six targets, composed of four focal ecological systems and two major grouping of species, chosen to represent the Delta's rich biodiversity:

- Brackish tidal marsh
- Freshwater tidal wetlands
- Riparian/Floodplain
- Northern claypan vernal pools
- Native resident and anadromous fishes
- Migratory waterfowl, shorebirds, waterbirds and riparian landbirds

At present, Staten provides significant habitat for only the last of these targets, migratory birds. This target is defined in the Delta CAP (Table 1) to include the following bird groupings: Cranes,

Rails/Moorhens, Passerine Marshbirds, Shorebirds, Dabbling Ducks, Coots, Surface and Plunge Divers, Grebes, Pelicans, Cormorants, Herons/Egrets and Ibis. A complete listing of nested target species for each of the six Conservation Targets can be found in Appendix 2 of the Delta CAP.

Figure 4. Map of Delta wetlands, including flooded agriculture. Originally published in 1994, and reprinted in 2001, by the Delta Protection Commission. A more current map is needed.



Appendix 1 of this report presents an Agricultural Habitat-Bird Matrix for Staten Island. This matrix serves as a starting point for characterizing how birds utilize the agricultural habitats that are made available with the current cropping arrangement. It provides information on the habitat that is found in different crop fields during different months of the year and describes the habitat structure in terms of the approximate height and density of the plants and also the soil moisture conditions and irrigation methods. Crop information was provided by B. Tadman, Staten Island Ranch Manager, Conservation Farms and Ranches. The matrix also indicates what bird species or species groups are expected to

utilize these habitats. Bird occurrence patterns were derived from expert opinions of avian ecologists at Audubon California (R. Kelsey, A. Hartman) and PRBO Conservation Science (D. Shuford), and should be viewed as preliminary until substantiated by onsite data collection. A field study currently underway will provide such data. Details on this study are provided in the *Research and Monitoring* section below.

In a literature review of crop use by waterbirds Taft and Elphick (2007) found that in North America, corn fields are used by a moderately diverse group of birds, primarily waterfowl, but also cranes, shorebirds, and some landbirds (mostly blackbirds). One study in southern Quebec documented 90 bird species in cornfield habitats during migration and breeding (Kirk et al. 2001). Table 4-1 in Taft and Elphick (2007) summarizes the occurrence of species in corn for all of North America. Tundra Swans (Tate and Tate 1966, Paullin 1996), Greater White-fronted Geese (Ely and Dzubin 1994), "Aleutian" Cackling Geese (Stabins et al. 2002), and Northern Pintail (Miller 1985) are among the common waterfowl feeding in California (BCR 32) corn fields during fall and/or winter. Many landbird species have been documented using corn fields and their associated habitats in North America. Raptors, Mourning Dove, swallows, corvids, certain wrens, American Robin, certain warblers, sparrows, icterids, finches, and introduced European Starlings and House Sparrows account for most of the documented landbirds reported in corn fields.

The waterways and riparian zone surrounding the Staten Island currently provide open water and brackish tidal marsh habitat that is utilized by a variety of species. However, this habitat is currently of limited value to the species that are the focus of conservation efforts in the Delta, such as native resident and anadromous fishes (AECOM 2010). The tidal marsh is only present in small pockets, and the riparian zone has few native species, and almost no trees or shrubs.

It is nonetheless worth noting that future restoration work could significantly enhance the value of some of the island's degraded habitats. Later in the document restoration scenarios are presented that could benefit additional Delta Conservation Targets including brackish tidal marsh and riparian/floodplain, and associated species.

Sandhill Cranes (*Grus canadensis*), the primary conservation focus at the island, use Staten for approximately six months each year, from early September through early March (Ivey and Herziger 2003). Individual color-marked greaters have been recorded on-site for nearly five months. Wintering sites are thus very important to cranes as they provide a significant portion of their annual life history needs. Ivey and Herziger (2003) studied crane movements in the Delta throughout the winter, and found that Staten was a keystone feature of the crane habitat landscape. Although for many individual cranes, Staten was not used in isolation from other sites, some marked greaters used Staten exclusively. In winter 2002-2003 peaks of 8,552 feeding and 7,987 roosting cranes were recorded, which represented 36% of the feeding crane use of the North Delta (north of Highway 12) through the entire winter, and 53% for the core wintering period of November-January (Ivey and Herziger 2003).

Certain sites in the Delta are critical to greaters (e.g., Staten Island, Brack Tract, and Stone Lakes National Wildlife Refuge [NWR]). This subspecies has strong philopatry to traditional use areas, with some individual color-marked birds known to have used the same very local wintering areas for at least 18 years, highlighting the importance of maintaining these areas (Ivey and Herziger 2003). Marked greaters observed wintering on Staten nest in states where the subspecies is listed as Endangered (Washington), Threatened (California), Sensitive (Oregon), and Vulnerable (British Columbia, Canada). Approximately 1,500 greaters used Staten, which is a significant portion of those using the

Pacific Flyway, representing at least 15% of the entire Central Valley Population (CVP) of greater sandhill cranes.

Sandhill cranes forage in newly-planted winter wheat fields (for about 3 weeks post-planting) which is planted from late October through November, depending on moisture conditions and the corn harvest schedule. In the spring, wheat fields provide nesting cover for ducks, ring-necked pheasants (*Phasianus colchicus*), and potentially short-eared owls (*Asio flammeus*) and northern harriers (*Circus cyaneus*). Wheat fields provide nesting habitat for some songbirds and are harvested in late July after most songbird chicks have fledged.

In recent years, large foraging flocks of geese have utilized the irrigated pasture and the corn fields. They have increased in number significantly since 2000 (G. Ivey, *pers. comm.*). More Aleutian Cackling Geese, currently the most numerous goose species on the island, are present. This apparently is a reflection in a booming population of this subspecies since foxes were removed from their nesting islands (D. Shuford, *pers. comm.*). They also appear to be showing up earlier in the season than previously.

Surveys for special-status species were conducted in 2002 and 2003 and are reported on in a report by May and Associates (2003). In this report the authors conclude that the following wildlife species have either been recorded or have the potential to be present on the island:

- Valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*),
- Western pond turtle (*Clemmys marmorata*),
- Double-crested cormorant (*Phalacrocrax auritus*),
- Great blue heron (*Ardea herodias*),
- Great egret (*Ardea alba*),
- Snowy egret (*Egretta thula*),
- American bittern (*Botaurus lentiginosus*),
- Black-crowned night-heron (*Nycticorax nycticorax*),
- Aleutian Canada goose (*Branta canadensis*),
- Cooper's hawk (*Accipiter cooperi*),
- Sharp-shinned hawk (*Accipiter striatus*),
- Swainson's hawk (*Buteo swainsoni*),
- Red-tailed hawk (*Buteo jamaicensis*),
- Northern harrier (*Circus cyaneus*),
- White-tailed kite (*Elanus leucurus*),
- Prairie falcon (*Falco mexicanus*),
- Greater sandhill crane (*Grus canadensis tabida*),

- Great horned owl (*Bubo virginianus*),
- Short-eared owl (*Asio flammeus*),
- Western burrowing owl (*Athene cunicularia hypugea*),
- Pacific slope flycatcher (*Empidonax difficilis*),
- Loggerhead shrike (*Lanius ludovicianus*),
- California horned lark (*Eremophilia alpestris actia*),
- Cliff swallow (*Hirundo pyrrhanata*),
- Tricolored blackbird (*Agelaius tricolor*), and
- Modesto song sparrow (*Melospiza melodia mailliardi*).

Although a multitude of species either currently occur, or have the potential to occur, on the island, May and Associates (2003) highlight the importance of the island to cranes:

> *"With transition to The Nature Conservancy ownership in 2003, the preservation of Staten as a feeding and roosting site for wintering sandhill cranes is imperative, as a substantial number depend on the island. Staten has become even more important for cranes as other use areas in the Delta and to the north are being lost to conversion to incompatible crops and urban development. If properly protected and managed, Staten will continue to significantly contribute to the welfare of Pacific Flyway sandhill cranes and serve as a demonstration area to show how farming and wildlife can coexist."*

5. Current Threats to Conservation Targets

Because Staten Island is owned by TNC and operated by a single entity (Conservation Farms and Ranches) that manages the land with the needs of wildlife in mind, it does not directly face certain threats that may be widespread elsewhere. For example, there is not a threat of Staten being converted to incompatible crops, as is the case at other similar properties in the Delta. However, incompatible agricultural practices should still be viewed as a threat to the wildlife that use Staten, because most species that utilize the island (e.g., for roosting) are also dependent upon surrounding properties (e.g., for foraging, Ivey and Herzinger 2003). Even though Staten has a suite of different habitats that are managed to meet the full complement of life history needs of the species that overwinter there, there is simply not enough habitat on-site to sustain populations at the desired levels. More cranes and other waterfowl use Staten currently than could be supported by this site alone. Wildlife at Staten thus face the very significant threat of increased isolation from other wildlife friendly farms and natural areas (e.g., marshlands). Already the distribution of seasonally flooded agriculture and marshlands is highly fragmented (Figure 4) compared with the historical condition in which there were large expanses of marsh habitat. Incompatible crops that appear to be on the increase in the Delta include cherries, grapes, and vine olives (B. Tadman *pers. comm*.)

Major on-site threats to the habitats at Staten Island include levee failure and reduced water quality. Both of these are described at length below.

Other on-site threats to the conservation targets at Staten are fencing and powerlines. Both of these structures (as well as the nearby towers on adjoining islands) are known to cause mortality to cranes, following collisions, especially on foggy mornings. The following suggestions were made regarding fence management by G. Ivey (in a letter dated 07 September, 2006): Design the fencing so that it is along the main roads and ditches, or at the toe of the main levee to reduce the risk of collisions. If cross fencing is needed in the center of fields, consider using temporary electric fencing. Also consider using fencing that can be laid down when the cranes are present, as has been used in Idaho.

6. Current Land Use and Management Structure

Of the 9,200 acres (3,725 ha), approximately 8,419 (3,409 ha) are suitable for farming on 153 fields ranging in size from approximately 12 to 124 acres (4.9-50 ha) (Figure 5). The remaining land is composed of levees, roads, ditches, canals, buildings, and operational facilities. Included among the latter is the granary site at the north end of the island, including a dryer, six silos, and flat storage with a combined storage capacity of 10,000 tons. The grain silos were built about 1950, the flat floor warehouse in 1964, and the dryer in 1983.

Staten Island has a complex irrigation system, with approximately 30 miles (48.4 km) of irrigation ditches, 81 miles (130.6 km) of drainage ditches (including 65 miles [104.8 km] of ditches between fields, and the 16-mile [25.8 km] main canal), 48 siphons, two discharge pump stations, and one river pump. Because farmed areas are below the water levels in the surrounding river channels, irrigation water delivery can be accomplished by gravity flow through a series of siphons to major farming units, and since it does not have a large associated cost (i.e., no cost to pump), delivering water to farm fields is less expensive and complicated than getting it out of the system. Irrigation tail waters accumulate in drainage ditches and flow to lower elevations at the southern end of the island, and are discharged back into the river system via pumps at the two large pumping stations. Pumping irrigation returns and water that seeps under the levees is expensive.

Currently there are ten year-round employees (one manager, two foreman, three shop workers, one office person and three field crew). An additional 12 to14 seasonal workers are required for crop planting and harvest. Operations and maintenance for a farm of this scale is costly and to minimize outside expenditures, property maintenance activities are completed in-house whenever possible. Habitat management and improvement activities are also generally carried out using farm staff and equipment; these activities provide opportunities for use of labor and equipment when not needed by the farm operation.

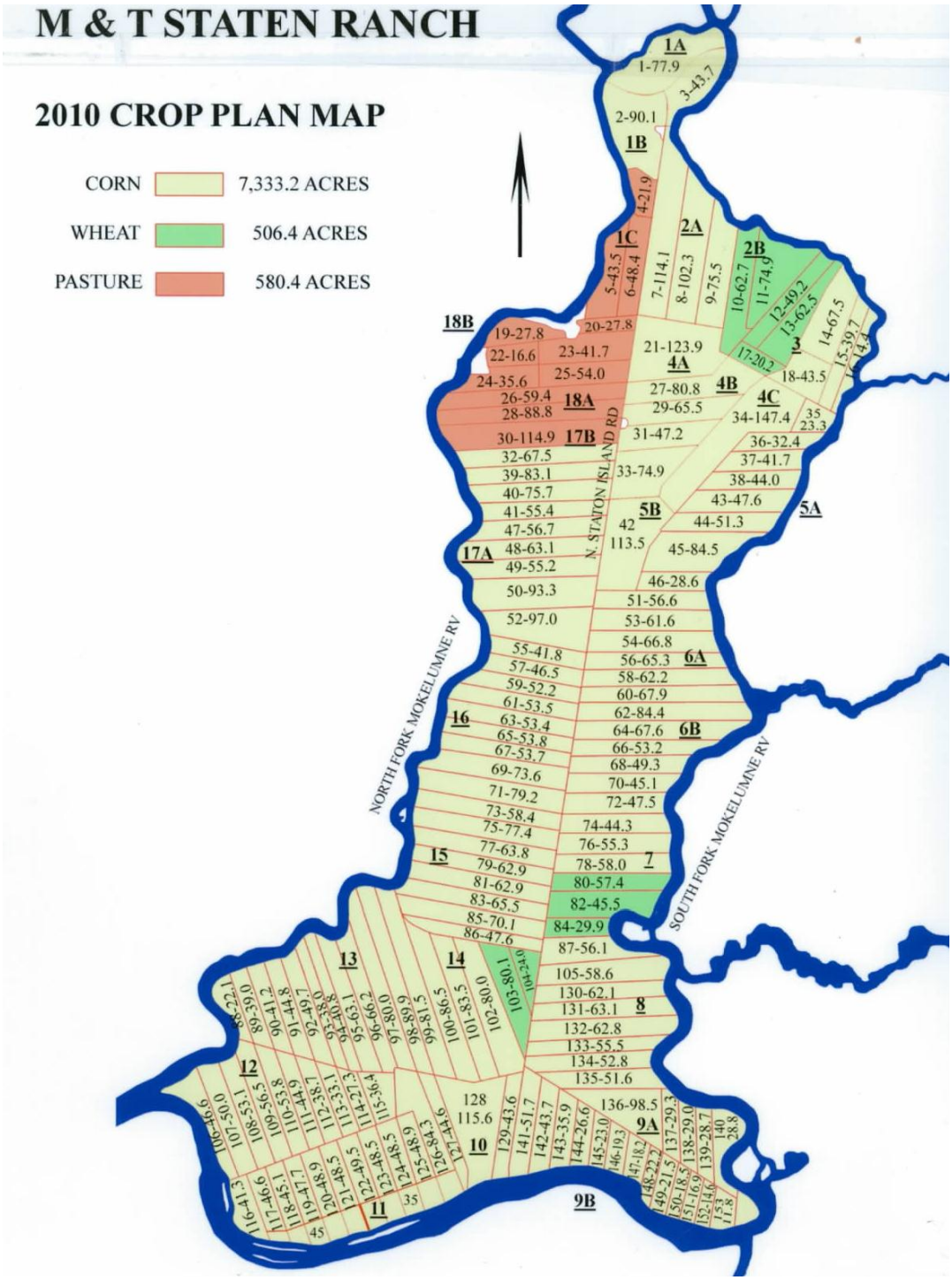
The current balance of agricultural crops at Staten is as follows:
Corn: Typically 75-89% of the total farmable acres is planted as roundup ready corn used for grain. *Bt* corn is not planted at Staten. In 2010 87% was planted as corn. Nothing is planted in the corn fields between planting cycles, although some corn fields are disked and transitioned to winter wheat each year.

Winter wheat: 4% to 12% of total farmable acres is planted in hard red or white winter wheat. In 2010 6% was planted as triticales, which is actually a cross between wheat rye and barley. Stripe rust is a problem that triticales seems less vulnerable to. In 2011, wheat will be planted again. There is a new strain that is supposedly somewhat rust resistant. A rotation between the crops may be desirable. Nothing is planted in the wheat fields between planting cycles. Fields are selected for planting of wheat so that they can be flooded in the September (prior to when corn fields can be flooded) to p[provide roost habitat for early arriving cranes. Field are also selected for wheat when they need to be leveled, as this is possible in the typically dry months following harvest.

Irrigated pasture: ~7% of total farmable acres is planted as a pasture composed of annual and perennial grasses and a mixture of clovers. Irrigated pasture is a new land use at Staten, first established in 2008.

Potatoes: In 2011 a limited area will be planted with Potatoes. It is thought that this will produce a nutrient “bump”. In the Klamath Basin potatoes are prone to fungal diseases; however, flooding (implemented as part of the “walking wetlands” program) has been shown to reduce outbreaks.

Figure 5. 2010 Crop planting map for Staten Island Ranch



7. Site-specific Management Considerations

Below is a list of major site-specific issues that should be considered when developing management plans for Staten Island. Many of these issues require further investigation.

Conservation Easement

TNC acquired fee title to Staten Island through two grants of funding provided by the State of California. Specifically the California Resources Agency awarded California Proposition 204 funds, and the Department of Water Resources awarded Proposition 13 funds. The California Resources Agency determined that the Staten Island project would contribute to the implementation of the CALFED Ecosystem Restoration Program by (1) protecting critical agricultural wetlands for continued use by significant numbers of migratory birds; and (2) allowing the development and refinement of economically viable wildlife–friendly agricultural practices. The Department of Water Resources determined that the acquisition of Staten Island and the continued management and use of Staten Island for wildlife-friendly agricultural purposes, along with TNC's agreement to participate in the North Delta planning process and potentially grant a flood management easement in the future in favor of the Department of Water Resources, would preserve agricultural land, protect wildlife habitat, and protect the floodplain from inappropriate or incompatible development.

Upon acquiring Staten Island on November 15, 2001, TNC granted an exclusive and perpetual Conservation Easement to the California Department of Water Resources which recognizes the multiple and complementary benefits Staten Island provides to the State of California for (1) agricultural land preservation, including the economic viability of agricultural operations; (2) wildlife habitat protection; (3) protection of a floodplain area from potential inappropriate and incompatible development; and (4) potential role in future flood management and water management improvements.

Of note, one of the obligations under the Conservation Easement is for TNC to "refrain from engaging in any actions that would result in the conversion of any material portion of Staten Island away from Agricultural use." This obligation may have implications for the extent to which habitat restoration is permissible on the island. However, material changes done in accordance with a restoration plan reviewed by the Delta Protection Commission and approved by the Department of Water Resources and the Resources Agency are allowed so long as the restoration plan is consistent with the preservation or enhancement of the multiple and complementary benefits of the Conservation Easement.

Another Department of Water Resources' requirement for the grant of funds to TNC, in addition to the Conservation Easement, was an agreement by TNC to participate in the North Delta Planning Process and potentially grant a flood management easement in the future in favor of the Department of Water Resources, pursuant to the terms and conditions of a Conservation Easement and consistent with the Flood Protection Corridor Program.

The North Delta Planning Process is a multi-agency planning process for designing and constructing floodway improvements pursuant to the CALFED Bay-Delta Program Programmatic Record of Decision. The Department of Water Resources' evaluation of alternatives for such floodway improvements in the North Delta may include use of all or a portion of Staten Island for future flood management projects or activities.

KSN Engineering conducted modeling that suggests that flooding the island would not attenuate the flood impacts to the degree needed to justify breeching levees. Nonetheless, at this time the State still has the right to require TNC to transfer a flood management easement should it so desire. The

agreement between the Department of Water Resources and TNC provides that any flood management project on Staten Island cannot irrevocably and or materially interfere with the habitat and agricultural values of Staten Island and flooding would only be permitted on Staten Island on an average of no more frequently than once in every ten years. If the preferred flood management project is the setback of levees, the limitation on frequency of flooding does not apply to those portions of Staten Island on the river side of the new setback levee. Currently, the agreement between the Department of Water Resources and TNC regarding the North Delta Planning Process and TNC's obligation to transfer a flood management easement to the Department of Water Resources expires in March 2012.

Economics

Management of Staten will also depend upon expected and actual economic revenues from agricultural production. Economic consequences of different management practices need to be ascertained both for the Farm, but also for the larger community. That is, we need to understand not only what impacts different farming approaches have on yields and economic returns for the ranch, but also what effects they may have on the entities that currently profit from working with the ranch. In addition there needs to be thorough consideration of additional revenue sources that may accrue from new activities, and the degree to which this may offset any losses. For example, if more of Staten is managed as seasonal marsh, and less as agriculture, then we might expect losses in farm income, and losses to the farm services sector (e.g., local agribusinesses, trucking industry, etc), but potentially increases in recreation and other ecosystem service revenues.

State Subventions

State subventions is a cost sharing program that has provided funds ($300 million per year) for maintenance of levees at Staten and elsewhere. However, 2009/2010 is scheduled to be the last year of the program. Fifth district Senator Lois Wolk is currently working on a bill to extend the levee subventions program using Proposition 50 funding. This program may also be funded through Proposition 84. In either case, future repairs will be treated as special projects, requiring all plans to be pre-approved before implementation.

If a new conveyance (e.g., a peripheral canal or a tunnel) is built, then the impetus to provide these funds may go away, as maintenance of the current island configuration in the delta would not be required to keep fresh water heading to the pumps. However, farmers in the Delta have water rights that are senior to the water diverters, and this may influence how state funds are appropriated. The state has coequal goals that call for the protection of the Delta ecosystem, farming interests, and water supply reliability.

Subsidence, Carbon Fixation and Green House Gas Emissions

The dominant cause of land subsidence in the Delta is decomposition of organic carbon in the peat soils. Prior to agricultural development, the soil was waterlogged and anaerobic (oxygen-poor). Organic carbon accumulated faster than it could decompose. Drainage for agriculture led to aerobic (oxygen-rich) conditions that favor rapid microbial oxidation of the carbon in the peat soil. Most of the carbon loss is emitted as carbon dioxide gas to the atmosphere (Deverel and Rojstaczer, 1996). Long-term subsidence rates in the Delta have been calculated to be 1-3 inches per year (Rojstaczer et al. 1991, Rojstaczer and Deverel 1993). Over the past century, agricultural land use practices in the Delta have oxidized more than 2.5 billion cubic meters of peat soils, causing subsidence down to 25 feet below sea level on some Delta islands.

Current agricultural land use practices in the Delta continue to oxidize the peat soils, emitting an estimated 10 to 15 million tons of carbon dioxide (CO_2) annually - approximately 3-5% of California's total green house gas (GHG) emissions. These are rough estimates that were calculated by the USGS from estimates of land area, amount of subsidence and carbon content of the peat soils (C. Ingram, *pers. comm.*)

The effects of farm management practices on subsidence need to be considered on balance with carbon emissions and other factors. For example, although pasture may be subsidence neutral, if cows are grazed, then carbon emissions may be high due to digestive reactions that take place with the manure produced.

Surface elevations at Staten Island range from sea level to nearly 16 feet (5 m) below sea level. The levees are well maintained (up to $500,000 is spent annually on maintenance) and meet DWR's Hazard Mitigation Plan (HMP) standards which calls for protection from floods that are 1 foot above 100-year flood height. Meeting this standard is necessary to qualify for subventions. Even so the island faces considerable flood risk. If the island floods it would be very costly to reclaim as farmland. It is likely that Staten is continuing to subside, although this has not been determined quantitatively.

At Staten and elsewhere in the delta there is the opportunity to use carbon capturing managed wetlands and conservation tillage practices to reduce or reverse subsidence and the emission of GHG. Per acre, freshwater emergent wetlands are the most carbon-rich landscape, exceeding even redwood forests by a factor of ten.

Estimates from pilot studies conducted in the Delta (Twitchell Island) suggest that managed wetlands on islands can sequester ~25 metric tons of CO_2 per acre per year and could continue sequestering new carbon at these rates until they reach sea level, in 75 to 100 years (C. Ingram, *pers. comm.*). The accretion achieved by these managed wetlands - up to 0.3 feet per year at the project site - provides local benefits in reduced levee maintenance and regional benefits in reduced risk of levee failure. However, more research is needed, for example, to look at methane, nitrous oxide and DOC production associated with marsh restoration.

To resolve remaining uncertainties, a farm-scale (200-300 acre) project was planned for Twitchell Island, to be implemented jointly by DWS and USGS. However, funding for the project was withdrawn during the bond freeze. In an effort to regain lost momentum on this project, a collaboration was formed between TNC (C. Ingram is lead), DWR, USGS, EDF, NRDC, Stillwater Sciences, Basic3, and Wetlands and Water Resources. Goals of the partnership are to: 1) Define and describe the potential for carbon capture managed wetlands to achieve economically viable GHG reductions in the Sacramento-San Joaquin Delta, including benefits, costs and risks; 2) Develop a "road map" for implementing carbon capture managed wetlands on a broad scale in the Delta, describing current status and recommended actions; and 3) Define and describe whether and how conservation tillage could provide GHG reductions on Delta peat.

Areas under consideration for this work include the southern portion of McCormack-Williamson Tract (owned by TNC), the northern portion of Staten Island and Dead Horse Island. The northern (upper) portion of Staten is under consideration because this area is less subsided than the southern portion. Theoretically this area could be restored to a tidal elevation in the relative near term, thus providing ecologically functional habitat and benefits to a suite of native aquatic species.

Pesticides and Herbicides

Various pesticides and herbicides are used in the conventional farming practices currently practiced at Staten Island. Agricultural return water is pumped from ditches that drain the subsided fields into the Mokulumne River, where it has the potential to adversely impacts water quality. The amounts and types of pesticides and herbicides used varies by crop type, and with environmental conditions; however, corn requires uses very little pesticide application for crop management compared to many other crops. When herbicides are applied on the property they are done so using the latest in GPS technology to avoid ditches and canals and are also applied in ounces per acre at times when minimal leaching/run off will take place. This is done in an effort to avoid leaching chemicals back into the water system. In 2006 DWR conducted numerous studies of discharge water from Staten and reports showed the water quality discharged matched the quality of the water imported into the island for irrigation (B. Tadman *pers. comm*.).

Methylmercury

The effects of different farm and flood management practices on methylmercury production need to be considered. Concern over mercury (Hg) pollution in the Sacramento-San Joaquin Delta (Delta) has resulted in posting of fish advisories recommending limited human consumption of sport fish. The Hg species of greatest concern to human health is monomethylmercury (MeHg). Human exposure to MeHg occurs primarily through the consumption of contaminated fish. Mercury cycling in the Delta is complicated; however, ongoing studies in the Delta have begun to increase our understanding of Hg sources, sinks, and processes. Recent research by Heim et al. (2009) suggests that outflow of water from Delta islands (including Staten) has elevated MeHg concentrations, relative to concentrations in surrounding waters, suggesting that Delta islands may be a source of this toxin. Although the generality of this finding needs to be confirmed, it is worth considering that Heim et al.'s (2009) publically available report on this topic may focus increased attention on water management at Staten.

Fish Entrainment

Irrigation water at Staten is derived from 48 siphons that draw directly from the North and South forks of the Mokelumne River. None of these siphons are screened. Thus it is likely that there is some entrainment of fish. Of particular concern is entrainment of Delta smelt, Sacramento splittail, and various salmonid species.

Recently a report (AECOM 2010) was completed that provides a preliminary evaluation of the potential for fish entrainment into irrigation siphon and pump intakes located in waterways surrounding Staten Island. The evaluation focuses on the potential for entrainment of fish species that are protected under the federal Endangered Species Act (ESA) and the California Endangered Species Act (CESA) and/or deemed commercially or recreationally important. The report characterizes aquatic habitats and fish use in the water bodies directly adjacent to the islands; characterizes and describes the siphon and pump intakes around the islands; and evaluates the potential for fish entrainment into the siphon and pump intakes.

Based upon review of available literature, the report concluded that channels in the study area primarily serve as migration corridors with some limited rearing (juvenile Chinook salmon, steelhead, delta smelt, splittail, and possibly green sturgeon) and spawning (delta smelt, striped bass, and splittail) habitat functions. Fish species of management concern and/or life stages that are most vulnerable to entrainment into irrigation siphon and pump intakes include outmigrating Central Valley fall-run,

juvenile Chinook salmon and Central Valley steelhead, adult and juvenile delta smelt, possibly juvenile green sturgeon, juvenile splittail, and juvenile striped bass.

Entrainment risk for fish species of management concern is anticipated to be low because the most vulnerable life stages are generally not present during periods when the siphons and intake pumps are operated. Fish species of management concern that are present in the study area during times when the siphons and pump intakes are being operated generally use open water areas and/or areas near the top of the water column. These areas are generally outside of the immediate area where intakes are located and suction could result in fish entrainment.

AECOM (2010) recommended that operation of siphon and pump intakes be reduced to the extent feasible during periods when there is overlap between the occurrence of the most vulnerable life stages of the different fish species. This period is primarily during May and June (emigrating salmonids) and to a lesser degree in December (adult delta smelt). It is also recommended that the rate of diversion be reduced to the extent feasible while still maintaining irrigation demand requirements. Because there is no empirical evidence to confirm the preliminary conclusions presented in this report, it is recommended that siphon and pump intake discharges be sampled with nets to document any fish entrainment that may occur.

8. Potential Future Conditions Given Climate Change and Other Factors

Planning management of Staten Island needs to give full consideration to expected future conditions. While the geophysical conditions in the Delta have been relatively stable in recent years, there are many reasons to expect that dramatic, unavoidable, and in some cases irreversible, changes are coming—**the Delta is at a "tipping point".** These changes may be caused by several interacting and complex factors including climate change, levee failures and water routing scenarios. Each has the potential to profoundly influence the Sacramento-San Joaquin River Delta of the future. Information on this topic is presented below, largely drawn from Lund et al. (2008).

- Sea level has been rising at the Golden Gate at a rate of 0.08 inches per year over the past century. Climate models project an increase in the rate of rise such that **sea level rise is expected to be ~1' by 2050, 3' by 2100** (Mount 2007). This will increase delta salinity. Increases of even 1' will greatly increase the cost of treatment of drinking water. With a 3' rise the delta would likely be unsuitable for agricultural irrigation. Problems will be greater in dry years with less outflow. It should be determined how much sea level rise is too much for growing different crop types at Staten and when this is expected.
- There is a **2-in-3 chance that a major (1906 magnitude) earthquake will occur in the next 30 yrs** (USGS n.d.). This could cause levee failures and island flooding. Effects of island flooding on salinity are expected to be variable and location specific. Flooding of islands in the western delta would cause the greatest increases in salinity. Flooding of eastern and southern islands would not necessarily cause any long-term changes in salinity.
- More precipitation falling as rain, as opposed to snow, will increase the magnitude of winter flood events, which will also threaten levees (Florsheim and Dettlinger 2007). Intensity of winter floods has already increased over the past 50 yrs. This increase has likely been caused by multiple factors including increased upstream urbanization, and potentially reduced channel capacity due to less channel dredging.
- **Half of the islands have a >95% chance of flooding over the next 50 yrs** due to combined effect of floods and earthquakes (Lund et al. 2008). If sea level rise is figured in then probabilities become even greater. Western islands are most at risk. Flooding these islands will lead to greatest increases in salinity.
- It is not cost effective to upgrade or repair most of the levees to protect islands from flooding. Exceptions include those with major infrastructure (e.g., railroad lines), or exceptional habitat values. Of note, Lund et al. (2008) identified Staten as an example of an island worthy of protecting—for the cranes.

- Upstream diversions of water (through a peripheral canal) are expected to reduce water quality in the southern delta as less Sacramento River water will be available to dilute the relatively polluted and saline discharge water from the San Joaquin River (Lund et al. 2008). The effect of this on waters surrounding Staten needs to be determined, but the expectation is that the quality of water siphoned onto Staten will worsen with a peripheral canal. However, Staten is part of the North Delta Water Agreement between the State of California and DWR that guarantees water in reasonable quality and quantity for beneficial uses.
- Greater variability in water flow and quality (and hence salinity, turbidity, etc.) as would result from a peripheral canal, may pose problems for agriculture. However, it may be good for much of the native Delta flora and fauna, as long as it doesn't become too salty. For native biota, there is currently too little variability in flows and salinity in the Delta.
- If Bay Area communities erect new levees (the most likely scenario) to protect infrastructure and other assets from sea level rise, then there will be much higher sea level rise and stronger tidal surge effects on the Delta than if the Bay is allowed to significantly expand its water surface area. Conversely, expansion of the Bay's surface as a result of salt marsh restoration (e.g., Suisun) or abandonment of shoreline structures could lessen the effects of sea level rise on the Delta (Lund et al. 2008).
- Moyle (2008) suggested that the increases in aquatic habitat caused by permanent flooding of the Delta's diked farmlands could be suitable for desirable native fish, such as delta smelt.
- The ecological consequences of island flooding will depend upon the extent to which alien species, particularly Brazilian waterweed (*Egeria densa*) and overbite clam (*Corbula amurensis*) become established. When abundant, these species can severely constrain ecosystem functions, and limit habitat suitability for flora and fauna (Moyle 2008).
- The long-term rising trend in water exports has constrained the natural variability in flows and other environmental conditions, facilitating the proliferation of aquatic alien species and the invasion of new species. The interrelationship of these processes appears to have tipped the system dynamics since the early 2000s. The low variability in recent years, potentially enhanced by the habitat-stabilizing properties of Brazilian waterweed and the long life span of the predatory largemouth bass, suggests that it will be hard to push the ecosystem back to a regime favoring desirable species without significantly altering Delta water management (Lund et al. 2008).

9. Current Management Practices that Affect Wildlife

Flood Management

During fall and winter, approximately 65-75% of the total dry field acreage at Staten is devoted to chopped and rolled grain stubble, newly planted winter wheat and irrigated pasture. The remainder of the acreage is flooded to provide roosting and foraging habitat. Harvested corn fields provide ideal foraging habitat for sandhill cranes geese and some waterbirds, primarily granivorous and grazing species. Terrestrial invertebrates available in corn fields may be an important resource for some shorebirds and landbirds, but corn kernels are by far the primary resource sought after by most waterbirds. High in caloric value, waste or ripening corn accounts for the majority of the diets of geese, cranes, and blackbirds that forage in corn fields throughout North America. A number of researchers contend that in regions where wetland habitat has been lost and natural food resources compromised, availability of waste corn has become increasingly important to the survival and reproductive condition of waterfowl and cranes (McLandress and Raveling 1981, Baldassarre and Bolen 1984, Krapu et al. 1995, Krapu et al. 2004). Krapu et al. (1995) even suggest that present-day geese arrive on Arctic breeding grounds in better physiological condition (greater and less variable fat reserves) than did geese prior to modern corn agriculture.

During the middle of the season (October through January) ~25-35% of the total grain field acreage is flooded to provide roost habitat. For cranes, Ivey suggests that 10-15% would be sufficient. However, providing more flooded habitat benefits other species, such as waterfowl. Nonetheless, flooding this

additional acreage likely reduces the carrying capacity of the island for crane foraging as waste corn is consumed more rapidly by waterfowl once flooding occurs.

One or more small (a minimum of 75 acres) roost ponds are typically provided in 3-5 fields by September 1st for use by early-arriving cranes. They are located in grain (winter wheat) stubble. Wheat fields are harvested in July. Early flooding also provides habitat for early waterfowl migrants including northern pintails [*Anas acuta*], greater white-fronted geese [*Anser albifrons*]) and shorebirds.

Corn fields cannot be flooded in early September because corn is not harvested this early in the season. Particular fields are selected for wheat planting with the expectation that they will be flooded. Only certain fields can be easily flooded due to a number of factors including location, whether they can be managed with internal levees, how readily they can be dried out, etc. Proximity of flooded fields to the main levee roads is also a consideration when selecting fields for flooding. Flooding near roads is preferable to flooding in the interior of the island because it enhances birdwatching opportunities.

Not many other farmers flood wheat and if they do, it typically happens later, after corn harvest. They flood to flush salts, for weed management, or for decomposition of crop residues. At Staten the only reason it is done early is to benefit wildlife (especially cranes). Other farmers don't flood early because they don't want to incur increased pumping cost that that arise due to high rates of evaporative water loss during this warm temperature period. In some instances there are no pumping costs, however, as water is simply siphoned onto the subsided fields. Farmers are also discouraged from flooding by mosquito abatement officials. As harvest progresses harvested grain fields are slowly flooded. The depths in flooded fields range from zero to >two feet.

Any individual field will have a variety of depths because they are all sloping. Many areas are too deep for cranes. For these areas to be shallower, other areas in the same field would need to be dry, which may not be tenable from a weed management standpoint. Deep areas are beneficial, in any case, in that they provide habitat for diving ducks such as canvasbacks (*Aythya valisineria*).

After the initial flooding of wheat fields, corn field flooding is staged to occur throughout fall and early winter, from late September through November. In 2010, flooding took place later, from mid October through December, due to the late harvest. Flood up is staged to allow cranes to access waste corn before flooding. This differs from what is done on most other farms where all fields are flooded rapidly and at the same time to prepare for the opening of duck season.

Mosquito abatement officials recommend fast floodups of fields. Rapid flooding inhibits weed growth and reduces emergent vegetation which is breeding habitat for mosquitoes. At Staten, fields are flooded slowly—over a period of 3-4 weeks for a large field. Mosquito breeding conditions are limited in these fields by reducing the height of crop residue. Corn stubble is chopped and wheat straw is baled, thus reducing the number of stalks that protrude above the water surface, and hence the area that mosquitoes have to attach their larva to. Slow floodups are done to benefit cranes and other wildlife. Cranes and other waterbirds take full advantage of slow floodups, following the water's edge (i.e., the "bug lines" between wet and dry areas) to forage on terrestrial invertebrate prey.

Flooding helps push salts up so they can be flushed from the fields when water is pumped out. To reduce the salt load in fields, fields are flooded more deeply than is optimal for cranes and other waterbirds and shorebirds. Yet the areas where there are excessive salts are localized, so that all areas need not be flooded deeply. Farm management staff at Staten recognize this as an area for improvement (B. Tadman, *pers. comm.*). Recently a new piece of farm machinery (a "rice border maker") was purchased so that small levees can be constructed around salty areas. This will enable

problem areas to be isolated for treatment, as opposed to having to deeply flood entire fields. Winter flooding could be a practice that is outreached to other farmers. It has the benefit of reducing salt concentrations in fields, and may provide revenues from hunting or wildlife viewing.

In the past, water levels were sometimes drawn down in selected fields and then refreshed with new higher quality water. This helped flush salts from the soil, and reduced outbreaks of bird diseases such as avian cholera. Farm management staff refers to this practice as "constant refreshing".

Water is drawn down slowly on a limited basis starting in January, however small roost ponds are left in important crane use areas and until March. Cranes begin departing the island in appreciable numbers in early February, with mass migrations occurring around the second week of February. Having a wide distribution of roost sites across the island is considered important. Consequently, attempts are made to retain ponds on the north, middle and south portions of the island until the end of the crane season.

Because open water areas on Staten Island are not treated for mosquitoes during the winter months, the full complement of aquatic invertebrates is allowed to develop. However, Mosquito abatement does control spray with a larvacide on habitat ponds in early fall until the average daily temperature drops.

Irrigation and Grazing Management of Pasture

Typically hay is cut in early April on about half of the irrigated pasture (250-300 acres). Cattle start arriving on the uncut fields in mid April, and additional cattle are brought in once the fields cut for hay regrow. Irrigation is continuous from May through October. Fields are grazed in a rotation that typically lasts 10 days. Pastures are flood irrigated every 15 days on average. Cattle are normally removed from the irrigated pastures between late October and the end of November, with the exact date depending on grass and field conditions. If an abundance of rain falls in October then irrigation will be stopped and cattle will be removed so they do not damage the fields. Fields have not been irrigated past October since the pasture on Staten was implemented.

Post-harvest Crop Residue Management

A conservation tillage system is practiced at Staten whereby corn residues are chopped and spread over the soil surface. Conservation tillage is a light disking which leaves some crop residue on the surface, whereas plowing is a complete physical flipping of soil. In addition to this practice hindering the growth of weeds during winter, conservation tillage provides a food crop residue for wildlife. It also benefits farming operations as requires fewer passes over the fields with the tractors, thus reducing labor and fuel costs, reducing wear on machinery, and providing better soil tilth (less compaction). Conservation tillage (including chopping and rolling of stubble) is a practice promoted by the NRCS EQUIP program. At Staten it is done after harvest in the fall, and again in the spring starting in the 2nd or 3rd week of March, and lasting though the end of spring planting season in May. In the spring, fields are chopped and rolled, then ripped to a depth of 16" to fracture the soil for root growth, and to help in sub irrigation, then fertilized, and then planted.

Conservation tillage may also provide an opportunity to reduce green house gas (GHG) emissions in the Delta. Soils are the largest reservoir of carbon of the terrestrial carbon cycle. They contain about three times more carbon than vegetation and twice as much as that which is present in the atmosphere. Differences are likely even more pronounced in the carbon-rich peat soils in the Delta. By converting to less intensive land-use practices, such as conservation tillage, farmers may be able to reduce their net GHG emissions. These changes offer the potential for GHG reductions that can be implemented over relatively short time periods and for relatively low cost. Though unlikely to have the GHG reduction potential of carbon capture managed wetlands, these practices could provide significant

GHG emission reductions for the Delta and halt or significantly reduce subsidence, particularly in areas where managed wetlands may not be feasible.

The tops and bottoms of the flooded corn fields are disked during harvest so that farm equipment can turn around. During flood-up, these areas provide bare mud habitat that is utilized by shorebirds for at least a short duration. Water that is used to flood fields typically enters from the top end and thus wets these bare dirt areas. Once fields are flooded, the upper areas may dry up, unless they are wetted by winter rains. When fields are dewatered, shorebirds appear to utilize these areas, unless they are dry. Other farmers also disk their turn around areas, however they less often flood their fields.

A significant change from ~2000 is that now after the corn fields are harvested, they are rolled to knock down the stalks. This practice is not employed by many other farmers. It appears that geese and cranes prefer this residue management practice because it gives them better access to the waste grains and may allow better visual detection of predators than fields that are left with standing corn stubble after harvest. Focused research on this management practice is currently underway (see below). This technique may also be beneficial from a farm management standpoint. Because the residue is in contact with the soil, it decomposes more readily than if it is left standing. So even if the fields are not flooded the stalks decompose which saves cost by reducing the need for mechanical field preparation. This may be a win-win, for wildlife and agriculture, and may be a practice that other farmers could be convinced to try (B. Tadman *pers. comm.).* Another benefit of chopping and rolling is that it appears to reduces soil erosion compared to leaving stubble standing.

Although chopped harvested corn stubble is more attractive to foraging cranes and geese, unchopped stubble provides some winter cover, which might be important as a thermal refuge for smaller birds. All field edges (8-10 rows) that are along irrigation and drain ditches are left as unchopped harvested corn to provide this cover habitat. Cranes will use unchopped areas, however they are not preferred over chopped areas (G. Ivey *pers. comm.*).

Fall and winter (September—February) plowing is no longer done anywhere on island, except to prepare fields for planting of winter wheat. In the Delta where there are not moisture or compaction issues, there is less of a need overall to do fall plowing than in areas with more mineral soils. Although plowing buries waste grains making these food resources unavailable to waterbirds, it provides a short-term increase in access to terrestrial invertebrates that may be important to shorebirds and landbirds. Over the longer term, however, research suggests that no-till fields support more invertebrates (Taft and Elphick 2007).

Although the mosquito abatement officials like to have soils in fields that are intended for flooding plowed or disked, this is not done at Staten. The concern with leaving fields undisked is that crop residue that protrudes above the water line provides ideal breeding habitat for mosquitoes. At Staten rolling after chopping reduces the amount of residue that rises above the water surface.

Preparation of Fields for Planting

Spring plowing is done on a subset of the fields, and typically occurs from mid-March through the first week of May, prior to planting. A variable percentage of the fields are plowed, depending on field-specific conditions. Efforts are made to minimize plowing due the cost and because it subjects the fields to wind erosion (and causes subsidence). In general, pre-planting field preparations are done in a more efficient manner than on traditional farms. Traditional farms typically employ a method that involves 4 steps: disking, plowing, chiseling, and fertilizing. Each step is accomplished with a separate pass of machinery. At Staten pre-planting is now done with one pass. Two tractors plant 12 rows at a

time each, whereas before three tractors were needed to plant 24 rows (8 each). In part, this is accomplished because there has been a shift from 36" rows to 30" rows. A shift to more modern equipment that is wider and more efficient and that utilizes cleaner burning engines is helping to reduce the farm's carbon footprint.

On Staten, winter wheat is planted at an increased rate of 25% to compensate for losses from foraging birds. This allows for heavy crane use, but still results in a good crop yield.

Weed Management

Winter weeds are kept to a minimum within the interior of farm fields to discourage spring nesting of ducks within the fields. Nests that become established may be lost to standard agricultural practices.

Where possible, flooding of fields is used through the winter as another weed control method. However, spot spraying is periodically needed in problem areas. Light disking is also used in some wheat fields where water is too shallow to control weeds and in some corn fields before spring planting. Because mallards (*Anas platyrhyncos*) begin nesting in March before fields are worked up for planting, Roundup® is applied to most fields to keep weed cover low and create a mulch layer which impedes further growth and holds soil moisture. This method reduces cover and discourages nesting ducks from using these areas where nests would later be destroyed by tillage. After the corn is approximately 6-10" tall Roundup® is again applied.

The vegetation maintenance strategy for landside levee vegetation is to allow for maximum upland nesting and cover during the times when cropland is not hospitable, but in the course of the year vegetation eventually needs to be removed to allow for levee inspections. To reduce vegetation on levees, herbicides for broadleaf weeds are used during winter months and grazing of sheep is used during the summer.

On the main levee, the herbicide 2,4-D® is used from November until March. January and February are the best times at Staten to kill broadleaf weeds and encourage grass cover. Grass provides better nesting cover for pheasants and ducks and allows sufficient visibility for levee inspections.

Previously sheep grazed in some of the grain fields; however, this practice was stopped due to concerns about sheep consuming waste grain that would otherwise be available for waterbirds. Sheep grazing on the main levee begins in late May, and takes place south of the areas used for horse pastures on the northern 1/4 of the Island. See the recommendation for further delaying grazing in the *Existing Restoration Opportunities* section below.

Irrigation Ditch Management

After the corn is approximately 6-10" tall spud ditches are dug for irrigation. Corn is usually irrigated 3 times from mid May until around the 10th of August depending on weather and growth patterns.

The larger irrigation ditches at Staten are used fairly extensively by duck broods during the springtime. However, they are not ideal duck brooding habitat, as ducklings are more vulnerable to predators than in natural marshlands. At Staten actions are taken to improve conditions for ducklings utilizing these features.

For example, water levels are held higher in the ditches during the early growing season than is needed for agriculture. This enhances conditions for waterfowl broods by allowing ducklings to more easily escape to vegetation along the banks. Also to help ducklings escape predators, ditches in wheat fields are constructed in a V-shape instead of in the steep-sided "spud ditch" style typically used by farmers in the region. The excavator that does this work straddles the ditch instead of cleaning it from the side,

allowing more of the streamside vegetation to remain. Generally, ditch-side vegetation is left for wildlife cover when cleaning ditches, and in some cases, emergent vegetation is also left.

At Staten the larger ditches are configured with banks somewhat sloped and are wider, shallower, and weedier than most farmers would tolerate. This allows ducks and other wildlife to leave the ditch and hide in nearby cover when predators approach.

About 20% of the permanent ditches are scraped clean of vegetation during the winter in any given year, while the main canal is dredged every 10-15 years. Clearing vegetation is necessary to maintain capacity and field drainage; however, not cleaning all the ditches annually ensures that some cover is available every year.

Hunt Program Management
A maximum of 12 hunters are allowed on Staten at any one time during the authorized hunting period. Duck season usually runs from the second or third week of October through the third week of January. In recent years, hunt days were Saturdays, Sundays, and Wednesdays. Ten blinds were located in flooded grain fields throughout the island. Dry field goose hunting took place in the past, but is no longer allowed so not to disrupt feeding or loafing cranes or other birds.

Because several blinds were assigned to employees whose only day off was Sunday, hunting was very limited. Waterfowl hunting was not permitted after 10:00 A.M., and hunters were strongly encouraged to be out of the hunt area before this time to minimize conflicts with mid-day loafing cranes. This timetable is not, however, enforced for hunters out in the flooded fields setting up decoys and working on their blinds. Hunters sign in and out on the days that they hunt and they record their take by species. This record keeping was started prior to the 2008/2009 waterfowl season.

Upland game hunting (pheasants) is limited to weekends during upland game season (first weekend of November through third weekend of December). Hunters are permitted to walk with dogs. No ATVs or horses are allowed. Hunters must avoid areas of roosting, feeding, and loafing cranes. Pheasant hunting occurs mid-day in the feeding fields when most cranes are loafing in the flooded fields.

10. Alternative Management Practices without Changing Land Use

This section is intended to identify alternative field management practices that have the potential to increase the habitat value of the croplands for target species under current land use. Currently this section is largely blank. Suggestions for practices to include are welcome.

Fall burning conventionally practiced in lieu of plowing may increase access to waste corn resources by removing cornstalk residue without destroying ears and kernels. And winter foraging geese have been known to select burned fields even though unburned fields may harbor greater amounts of waste corn. This is moot, however, as it is currently illegal to burn in San Joaquin county. Also, because soil on Staten is largely organic, burning crop residue will also burn some of the soil thereby changing its composition and causing further subsidence.

11. Alternative Land Use Opportunities

As an agricultural property in the Delta, Staten has a wide range of crops that could be planted on it. There are considerable wildlife benefits associated with the current cropping arrangement, however, farming other crops (e.g., alfalfa) could also benefit native fauna. To a large degree Staten was purchased to provide winter habitat for Sandhill Cranes. Corn fields and pasture provide habitat for cranes, but so to do other landcover types. More needs to be done to evaluate what crops are most important to grow at Staten, and how to best manage these crops for wildlife. Additional consideration

also needs to be made of the agronomics of infrastructure, equipment and labor associated with different cropping matrixes on the island.

The following two tables were made from data taken from Rich (2006). The first reports the number of acres of field crops that were planted in the Delta, by County, and in total, from 1998-2004. Although this information is somewhat dated, it is useful as a list of alternative crops that could be planted at Staten. Alfalfa, corn, corn silage, wheat and irrigated pasture are the predominant field crop types in the Delta. This table also presents (in the last row) a measure of the short-term profitability of field crops – contributions to fixed costs, or gross crop revenue minus variable production costs. According to Rich (2006) this is a better reflector or short-term profitability that net revenue. Rice and alfalfa ranked as the highest in terms of profitability during this time period for field crops.

The second table reports similar information, but for non-field crops. Wine grapes, tomatoes and asparagus were the main non-field crops planted during this time period and wine grapes and fruit and nuts ranked highest in terms of profitability.

Table 1.

1998-2004 Estimated Acres - Field Crops								**Average Contribution to Fixed Costs per Acre**
Crop	Alameda	Contra Costa	Sacramento	San Joaquin	Solano	Yolo	Entire Delta	Entire Delta
Wheat	-	1,710	4,500	24,152	4,105	5,500	39,967	90
Sorghum, Grain	-	-	900	-	-	-	900	-124
Barley	-	-	1,000	-	478	-	1,478	48
Rice	-	-	1,000	2,304	-	1,396	4,700	261
Corn	-	6,284	20,000	26,979	2,380	1,500	57,143	59
Corn Silage	60	-	10,000	27,306	-	-	37,366	180
Dry Beans	-	-	550	8,155	-	-	8,705	197
Safflower	-	936	5,000	2,872	6,534	2,000	17,342	150
Alfalfa Hay	770	3,520	8,500	44,973	5,543	7,100	70,406	305
Oat Hay	-	-	-	-	-	1,000	1,000	17
Grain Hay	700	1,140	1,200	3,120	476	476	7,112	58
Non-Corn Silage	-	-	-	3,232	-	-	3,232	83
Sudan Grass	-	-	-	-	207	-	207	204
Rye Grass	-	-	-	-	158	-	158	17
Irrigated Pasture	200	3,640	4,500	4,050	9,956	5,000	27,346	127
Misc. Field	-	1,749	765	1,101	1,007	4,261	8,883	233
Seed Crops	-	-	200	982	458	1,471	3,111	356
Total	1,730	18,979	58,115	149,226	31,302	29,704	289,056	

Table 2.

1998-2004 Average Annual Acres - Non Field Crops								Average Contribution to Fixed Costs per Acre
Crop	Alameda	Contra Costa	Sacramento	San Joaquin	Solano	Yolo	Entire Delta	Entire Delta
Tomatoes-Proc.	-	110	3,500	20,613	481	1,900	26,604	751
Tomatoes-Fresh	-	-	700	4,540	-	-	5,240	1,494
Sweet Corn	-	3,300	-	1,350	-	-	4,650	919
Cucumbers	-	-	-	1,559	-	-	1,559	1,076
Pumpkins	-	-	250	1,535	-	-	1,785	706
Squash	-	-	80	-	-	-	80	582
Watermelon	-	-	-	1,050	-	-	1,050	585
Cantaloupes	-	-	-	220	-	182	402	296
Onions	-	-	-	305	-	-	305	601
Potatoes	-	-	-	2,509	-	-	2,509	595
Asparagus	-	1,200	1,492	20,235	-	-	22,927	1,013
Misc. Vegetable	-	969	200	3,826	372	750	6,117	845
Apples	-	200	350	255	142	-	947	1,226
Apricots	-	490	-	700	-	-	1,190	373
Cherries	-	-	270	165	38	-	473	542
Peaches	-	-	-	109	-	-	109	183
Pears	-	-	6,100	32	316	-	6,448	993
Almonds	-	-	-	1,788	-	-	1,788	1,165
Walnuts	-	780	-	2,673	-	200	3,653	736
Wine Grapes	-	1,560	8,000	9,108	1,593	7,000	27,261	2,357
Misc. Fruit & Nut	-	77	80	410	98	350	1,015	1,874
Nursery Products	-	109	421	390	229	50	1,199	10,481
Total	-	8,795	21,443	73,372	3,269	10,432	117,311	

The crops grown in the Delta that are the most abundant are also ones that can support large numbers of waterbirds seasonally, i.e., alfalfa, irrigated pasture, and corn. Rice is also an important crop for waterbirds, but not a lot of it is grown in the Delta, and all of that is grown in the eastern portion, and hence is probably not a good candidate crop type for Staten. Grain and silage crops can be attractive for some bird species. For example, Tricolored Blackbirds frequently nest in grain and silage crops, but there is a downside in that harvesting of these crops can destroy breeding colonies. Northern Harriers can nest in such fields too, but in so doing they also run the risk of having their nests destroyed during crop harvest. Fields of many crops can support waterbirds if flooded after harvest. Non-field crops are the least attractive to birds, particularly orchards or vineyards.

As for what specific species of birds occur in which crop types, there is a lot of literature on use of rice by birds in California, but much less for other crops, though a more thorough literature review might turn up some useful information. The following website has some information on bird use by crops and lists references to consult for further information:
www.abcbirds.org/abcprograms/policy/pesticides/biaa/.

Alfalfa and irrigated pasture generally hold the same types of waterbird species, though this can vary across the seasons (D. Shuford, *pers. comm.*). When irrigated, both are used by many species of shorebirds, herons, egrets, ibis, Swainson's hawks, blackbirds, etc. Corn is very good for cranes and waterfowl, and shorebirds if there are some open mudflats or very shallow water areas. See Appendix Table 1 for further details on expected bird use patterns in corn and irrigated pasture.

It might be worth considering complementing the corn and irrigated pasture at Staten with alfalfa, particularly as this crop can be attractive to waterbirds at during periods of peak use at the island. Approximate seasonal use patterns are as follows: corn (winter), irrigated pasture (year-round), alfalfa (during the irrigation period of spring to early fall).

There is a pressing need for more detailed Central-Valley specific information describing when during the year particular crops (e.g., corn, alfalfa, rice, etc.) provide habitat to birds, and how this varies by species. Characterizations of how the physical structure (height, density, etc.) of the crops change through the growing season should be made so that predictions of bird use patterns can be generated. These predictions should state what the habitat is expected to be used for (e.g., roosting, nesting, foraging) by particular species. Because irrigation practices are likely to influence bird use patterns, these should also be described. In addition, harvest schedules should be included, as this influences whether or not nesting species will be at risk. Harvest also produces fundamental changes in habitat structure and may affect food availability, factors that birds are highly responsive to. Although highly important, none of this information has been assembled for crops grown in the Delta. The Delta Working Group of the Central Valley Joint Venture may be the most likely group to spearhead such an effort, as they are initiating a "Delta vision process for migratory birds". This vision may include recommendations for various crop types and amounts for the Delta of the future (C. Hickey *pers. comm.*). Regardless, we have begun to assemble this information for Staten Island through a monitoring study that was initiated by PRBO in fall, 2010.

12. Enhancement and Restoration Opportunities

Existing Restoration Opportunities

These are potential habitat-improvement projects that focus on the areas outside of the agricultural fields. They assume a continuation of existing land uses and do not require taking any land out of production.

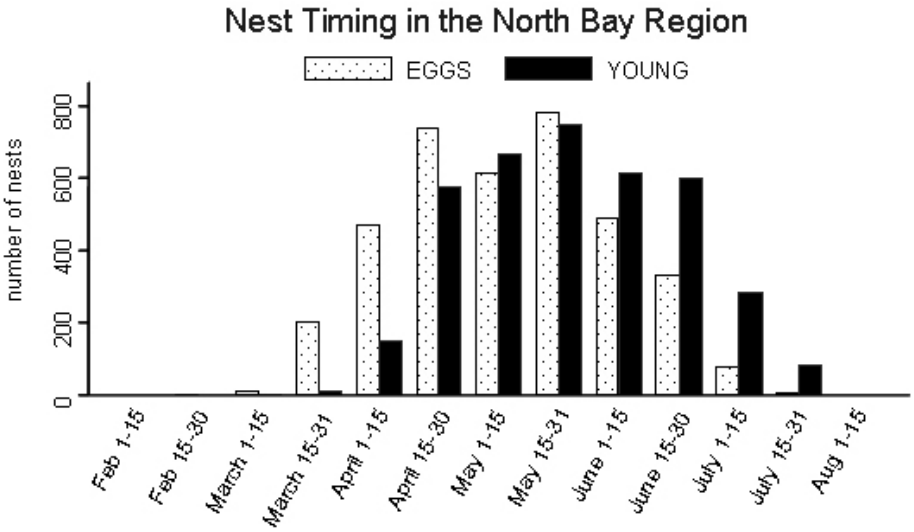
There are many opportunities to improve habitat on Staten seemingly without impacting agricultural operations. Some of the habitat enhancement work that could be done has been successfully implemented elsewhere (e.g., McCormick Williamson). Funds for some of this may be available through existing state and federal programs (see funding section below). Some of the restoration opportunities described below fit well with the area of expertise and experiences in Audubon's Private Lands Stewardship program. A few specific opportunities are introduced below.

a) The dry side slopes of the levees present an opportunity for restoration. They currently offer relatively low habitat value, also some nesting does occur on them. Poison hemlock (*Conium maculatum)* is currently widespread (see below image). Goats graze these areas seasonally. Habitat value for many species could be improved by planting native species.

A complicating issue is need to inspect the levees, so perhaps no trees should be planted. It is interesting to note, however, that a fair number of trees on the outboard side of levee at northeast end of island. Also, one willow thicket is located on the flats inside the levees in this general area. Perhaps trees can be planted if they are kept clear of branches near ground level. Even if trees aren't planted, native grasses and herbs such as mugwort, deer grass, and stinging nettles could be. Tricolored Blackbirds are known to nest in extensive patches of nettles (D. Shuford, *pers. comm.*). Some levees are broad sloping, and these present the best opportunities. LiDAR data of the island could be used to define levee slope angles. There are 26 miles of levees on Staten. Restoring them would yield significant gains in riparian habitat in this area of the Delta.

b) Delay grazing on the levee. As mentioned in the *Weed Management* section above, grazing on the main levee typically begins in May. This may result in losses of nests and chicks as landbirds in the Sacramento Valley and the North Bay Region nest from March through late July (Figure 6). The nesting season is a critical period in birds' lives. Habitat enhancement and management activities, such as grazing, disking, herbicide application, and mowing should therefore be limited to the non-breeding season—from September to February (Kreitinger and Gardali 2006, CalPIF 2008). Many songbirds nest very close to the ground in grasses and 'weedy' areas. Disturbances during the breeding season may result in nest abandonment, the elimination of nest sites, destroying nests, exposing nests to predators, and decreasing food sources such as insects. If there is a need to graze these areas then they should be grazed early (beginning in February) and often, as this will prevent birds from nesting.

Figure 6. Timing of the breeding season for birds in the North Bay Region. Data are total number of nests by first egg and hatching dates from 67 species at four sites in Sonoma and Marin counties; 1979-2005 (PRBO unpublished data). Figure from Kreitinger and Gardali (2006).



c) Irrigation ditches could be restored with hedgerow-style plantings. A complicating issue is the need to keep access for machinery to periodically clean them out, but perhapings could be put in on one side. Maintaining vegetation on ditches is not complicated on Staten as it is on many other places by the need to manage cows, as none are onsite, except in the pasture.

d) Stands of hardstem bulrush (*Schoenoplectus acutus)* are decadent in some places along wet side of the levee. This can be managed (burned or cut) to promote new growth. Many species, including Tricolored blackbirds, prefer vigorously growing bulrush to that which is decadent. Before such efforts are undertaken, however, it would be useful to investigate whether such patches would be of the extent needed by Tricolors and what habitat characteristics this species is responding to elsewhere in the Delta.

e) The pastures could be sub-irrigated about every 3rd week after the cattle have been removed, and until the fall rains come. Such irrigations make earthworms and other invertebrates available to cranes. The fields should not be completely saturated as this will drown all the invertebrates. This suggestion was made to Ranch Management by G. Ivey in a letter dated 07 September, 2006.

Expanded Restoration Opportunities

These are opportunities for creating larger natural habitat areas with some conversion of existing land uses (i.e., conversion to other crop types or taking land out of production).

a) Restore small lobes of unplanted area. These areas are too small to be productively farmed and present weed sources. Below is a picture of one such area. They could be restored with riparian plantings. Currently there isn't sufficient mapping of where these areas are. Locations should be identified and mapped with a GIS, and total acreages should be tallied to help determine the potential gains that could be made by restoring them.

b) Create wetlands. There are two fields (51 and 41 acres, pictured below) that could be appropriate as wetland restoration sites (B. Tadman *pers. comm.*). They are low lying areas that have a high buildup of salts in their soils. These fields are more difficult to flush the salts from than other fields. They are located on an alkali bench with poor drainage.

Additional locations for wetland establishment include the pastures. G. Ivey made the following suggestions in a letter to ranch management dated 07 September, 2006): I suggest you design some small seasonal wetlands within your pastures (3 or so about 5 acres each). These could be shallow-flooded during fall and winter and grazed by cattle during spring and summer. They would provide brood habitat for early nesting ducks and if reflooded in fall would greatly enhance the attractiveness of pastures to cranes. The wetlands could be developed by scooping out shallow depressions (1-3 feet deep) near the drainage outlets for the different fields. It would also be good to encourage native wetland plants (particularly sedges) in the pastures. This can be accomplished by keeping them pretty wet during the growing season by irrigating them regularly in rotation when the cows aren't present.

c) Plant Tule marshes. These areas would serve as habitat and could potentially reverse subsidence. If planted, detailed studies should be conducted to determine whether subsidence is indeed reversed, and how quickly land is accreted. These sites also have to potential to yield carbon credits—though these may not offset lost agricultural revenues. See above section entitled *Subsidence, Carbon Fixation and Green House Gas Emissions* for additional information.

d) Expand irrigated pasture. In 2010 there was approximately 580 acres of irrigated pasture on Staten. Cows are on the island from May until November and then are moved to Howard Ranch. Pasture is irrigated through spring, summer and early fall. On the pasture, herbicides are used to control Johnson grass. Fertilizers also used. These pasturelands provide good habitat for Sandhill cranes, long-billed curlews, Aleutian Canada geese among other species. They were planted at Staten in 2008. Revenues from the cow operation are slightly less than those from corn on a per acre basis when all costs are considered (B. Tadman *pers. comm.*).

e) Plant alfalfa. Alfalfa provides valuable habitat to waterbirds, and would likely complement the other habitat types present on the island. Generally speaking, alfalfa supports similar species to irrigated pasture; however, differences in management (e.g., irrigation and cutting or grazing cycles) likely translate to differences in microhabitat conditions, with resultant changes in bird use patterns. Also, the frequent cutting cycle of alfalfa, and close cropping at harvest, seems to provide a more diverse array of vegetation levels over time, such that pasture and alfalfa would likely be complementary in terms of the bird habitat they provide.

f) Set back levees. Another potential restoration action involves setting back levees at the upper end of the island where subsidence is minimal to provide more hydraulically connected floodplain, marsh and or shallow water habitat. Before implementing such a project, more needs to be done to determine specifically what habitat types are suited to the site conditions and what ecological targets they would support. Setting back levees may seem a radical idea, however, it may be worth considering given that habitat close to sea level is some of the most ecologically valuable—and shortest in supply—in the entire Delta.

g) Currently shorebird use of Staten appears to be relatively low, but likely could be enhanced by alternative management practices and crops. Migrant shorebirds are limited by habitat in July and August before much habitat is flooded in fall. Perhaps harvested wheat fields could be flooded in these months for shorebirds prior to arrival of waterfowl and cranes. In winter there also appears to be a shortage of shallow-water habitat for shorebirds. In corn fields during this season, there is relatively little open shallow water because the standard chopping and rolling covers large areas of the ground with corn stalk residues, leaving little access to mud for shorebirds. Perhaps more light tilling could be done to expand the bare headland areas to provide more shallow habitat free of extensive mats of residual vegetation. Alternatively, perhaps a few entire corn fields could be tilled and shallowly flooded to increase shorebird habitat. As noted above, planting of alfalfa would likely increase shorebird use in late summer and fall.

Below are a few general restoration recommendations for the Delta that pertain to management of Staten:

a) Overall there is a need to reduce inputs of pollutants, especially ammonium and pesticides, as well as warm water and salts, from regional agriculture and urban areas through education, incentives, better regulation, land retirement, and cap-and-trade systems.

b) It would benefit the Delta ecosystem if an inflow pattern could be created that is flexible enough to adjust to changes in physical ecosystem structure (e.g., island flooding) while providing the flows needed for desirable species to successfully complete their life histories (e.g., for spawning of delta smelt).

c) Provide "insurance habitat" should there be catastrophic losses at Staten or other Delta Islands. This could be done by creating large blocks of upland habitat on the margins of the Delta and by creating corridors to connect isolated patches of habitat. Such connections would favor terrestrial species, especially overwintering birds. Much of this land could be devoted to wildlife-friendly agriculture.

13. Previous and Ongoing Research and Monitoring of Bird Use of Staten

Studies of Crane Habitat Use Patterns and Movements in the Delta

A conservation assessment of greater sandhill cranes wintering on the Cosumnes River floodplain and Delta regions was completed by Littlefield and Ivey (1999). It includes an overview of crane use in these areas and discusses their significance for the species. It also provides recommendations for how agricultural lands can be most effectively managed to benefit cranes.

In the winter of 2002-2003 extensive monitoring of sandhill cranes and their habitat use was conducted by Ivey, Herziger and Gause as part of a short-term study in association with May and Associates, Inc. of Walnut Grove, California, under contract with TNC. The purposes of the study were to: 1) document baseline crane data for future management and projects, 2) determine the relative importance of wintering crane use on Staten compared with other sites in the region, and 3) assess how current and past agricultural practices have affected crane use and abundance in the Sacramento-San Joaquin Delta (Delta) of California and other areas just north of the Delta.

This study found that winter home ranges for greaters were relatively small, averaging less than one square mile (0.66 mi^2 [1.71km^2]), despite the constant changing food availability through the season. Flight distances from roost sites to foraging areas also averaged less than one mile (0.88 mi [1.42 km]), and were similar to previous crane surveys in the Delta, indicating the need for suitable roost sites in close proximity to feeding areas. Observations of movements of marked cranes also demonstrated the need for the presence of early and late season roost sites. In contrast, lesser sandhill cranes (*G. c. canadensis*) had much larger winter ranges and foraged further from roost sites. Therefore, the needs of this subspecies can more easily be provided for in a larger landscape (Ivey et al. 2003).

Crops grown on Staten (e.g., corn, wheat and tomatoes) and non-agriculture areas (e.g., levees and roads) were evaluated for importance to foraging cranes. Crane use and preference of different crop treatments shifted over time in response to changes in food availability, with chopped corn the most important for the entire season. However, harvested wheat with various treatments, newly-planted winter wheat fields, and a small wetland field were highly preferred at times; it was generally only after wheat fields were apparently fed out that corn crops became favored. Regardless of the crop type, cranes were very attracted to newly-flooded fields and the exposure of fresh dirt from the pushing up of levees which exposed rodents and invertebrate prey and provided crane foraging sites for short-term periods (Ivey et al 2003).

Wintering Ecology of Sandhill Cranes in the Central Valley

More recently a large project was initiated focusing on the wintering ecology of Sandhill Cranes in California's Central Valley. It delved further into the comparative ecology of the two subspecies of sandhills with a major emphasis on issues needed to design a biologically relevant management plan. During the past two decades, agencies and organizations have invested over 50 million dollars to establish refuges and preserves that protect habitats used by Sandhill Cranes in the Delta including the

Isenberg Ecological Reserves, Cosumnes River Preserve, Stone Lakes National Wildlife Refuge (NWR), San Joaquin River NWR, Twitchell and Sherman Islands, and Staten Island. Although cranes use these sites, it is not clear how they are using them, nor do we understand the relative importance of these properties to maintaining crane populations in the Delta Region. Detailed information on crane habitat requirements and movement patterns is needed to understand the critical links between these recently purchased properties and surrounding privately owned lands. Components of this project are being led by Gary Ivey and Bruce Dugger and are described below.

Gary Ivey of Oregon State University, in conjunction with USGS researchers at the Dixon Field Station are conducting a study was to compare winter movement patterns of sympatric greater and lesser sandhill cranes (*Grus canadensis tabida* and *G. c. canadensis*) wintering in the Sacramento-San Joaquin Delta region of California (Delta). They marked 31 greaters and 45 lessers with VHF radios and recorded their roosting and feeding locations throughout the wintering periods in 2007/08 and 2008/09. Ten of the lessers were also marked with platform terminal transmitters and tracked via the Argos Satellite System. Compared to lessers, locations of greaters were much more predictable. Greaters showed strong fidelity to wintering sites and moved between discrete wintering areas less frequently. During the second year of our study, 90% of the greaters returned to the study area, compared to 69% of the lessers. Only two greaters (7%) were located in more than one discrete wintering area, compared to 40% of the lessers. Average flight distances from night roost sites to feeding areas were lower for greaters than for lessers and consequently, winter home range sizes were smaller for greaters. These results have application for conservation of wintering cranes at a landscape scale and indicate that habitat protection and mitigation for the state-threatened greater sandhill crane must occur very close to existing use areas to be successful.

Bruce Dugger of the Department of Fisheries and Wildlife, Oregon State University and Robert Anthony, of USGS, are conducting a companion study focused on measuring food abundance and quality over time in major foraging habitats. Researchers converted all food abundance estimates to energy and generated an estimate the total food energy available around a roost. Sampling was focused on corn, alfalfa and pasture. Corn fields were sampled three times (once immediately post harvest, once during late fall and once during later winter prior to crane departure on spring migration), to document patterns of corn abundance during the crane wintering season. Researchers also sampled a subset of fields a fourth time, after post-harvest disking, to understand how this common agricultural practice influences waste corn availability.

Information on food abundance from this project will help explain the mechanism that results in the patterns we observe in habitat use and movements. Data on food abundance are also needed to project how land use changes will impact cranes, and to make recommendations regarding landscape composition needed to support cranes. Given the development pressures (urbanization, water) in California, these data are critical if we are to develop biologically justifiable conservation plans.

Evaluating the Influence of Post-Harvest Management Practices on Migrating and Wintering Waterbirds

The above projects all are focused on Sandhill Cranes. However, it I recognized (see *Conservation Targets* section above) that Staten provides important habitat for a wide suite of waterbirds. Yet little is known about their patterns of use on the island, and how these are influenced by different management practices. Corn and winter wheat are two crops known to benefit various bird species during winter and migration periods and they ranked fifth and third in total acres planted in California, respectively.

Still, there is little information regarding their use by different species, or how this is influenced by post-harvest management practices (e.g., chopping only, chopping and rolling, flooding, tilling).

To better understand this, TNC (G. Golet) contracted with PRBO Conservation Science to conduct a 2-year field study. Bird surveys are being conducted twice per month from October through March, starting in 2010, and continuing through 2012. They will document use by waterbirds (mainly cranes, geese, ducks, shorebirds, herons, egrets, and ibis) of agriculture fields under different post-harvest management practices. The surveys will quantify spatial and temporal variation in use of agricultural landscapes, and data analyses will discriminate among relative benefits to waterbirds of different post-harvest agricultural practices. In the future, these data can be used to develop an agronomic model for post-harvest management that aims to optimize both wildlife benefits and harvest yields. Likewise, post-harvest management practices for corn and winter wheat that are shown to benefit waterbirds in this study could be extended to other farming operations in the Delta and throughout the Central Valley.

14. Research and Monitoring Needs

Sandhill Crane Monitoring Recommendations

It is imperative that Staten continue to provide habitat for cranes, at least until the needs of this species are sufficiently well met at other sites. Meeting the habitat requirements of this species at other sites may be a desirable outcome, however, as this would remove some of the habitat management constraints currently in place at Staten. More specifically, it would allow for experimentation with alternative planting patterns, such as those that reverse subsidence, sequester carbon, and reduce greenhouse gas emissions. The current cropping arrangement is probably suboptimal for addressing these issues. It is therefore important that cranes be monitored both at Staten and regionally. This effort should be directed at determining specifically how cranes utilize the currently available habitats. Determinations should be made of the amount of the different potential habitat types are needed to support current and targeted population levels of the species. And because crane use differs over the course of the year, this information should be provided for each of the different seasons of use.

More detailed recommendations for Crane monitoring were provided by Gary Ivey in a letter (dated 29 June 2008) to the Central Valley Joint Venture Waterbird and Shorebird Subcommittee. In this letter Ivey recommends an expansion of the work that he was conducting at that time in his foraging ecology study. His research sites included Stone Lakes and San Joaquin River NWRs, Cosumnes Preserve and islands and tracts in the North East Delta, including Staten.

According to Ivey, data are needed on population status and trends of all three subspecies of cranes that use the Central Valley: the Greater Sandhill Crane (state-Threatened), the Lesser Sandhill Crane (CA Bird Species of Special Concern) and the Canadian Sandhill Crane. The latter is the rarest and has the smallest population. Unfortunately, we don’t have adequate data for these populations. The only valley-wide coordinated survey which counts cranes is the midwinter waterfowl survey; however, because the focus of the survey is waterfowl, some cranes are likely missed. Existing data shows great variation in numbers (15 to 49K from 2000 - 2007). Also, this survey does not differentiate subspecies. Ivey and colleagues used sampling statistics to develop a survey method for estimating the total crane population size.

Overnight roost sites are a key habitat component that determines crane foraging patterns, as cranes appear to select foraging sites primarily based on their proximity to roost sites. For conservation planning, it is important to know the locations of roost sites, understand levels of crane use, and their protection status. Efforts should be made to locate all crane night roost sites in the valley. Periodic

counts should be conducted of cranes using roost sites to assess changes in crane use. Efforts should also be made to survey cranes to document their foraging distribution within wintering areas in the Central Valley. Using this data, a valley-wide GIS layer should be developed with roost and foraging site locations and associated data (ownership, status, survey numbers, etc.) for use in conservation planning.

Other Bird Research and Monitoring Needs

More generally, it would be highly beneficial to better characterize seasonal avian use patterns in Central Valley and Delta croplands. This would involve describing in detail how different crops (e.g., corn, alfalfa, rice, etc.) are utilized by waterbirds (waterfowl, wading birds and shorebirds) throughout the year. A project focused on this would describe the physical characteristics of the various crop types at various stages during the growing season, as well as after harvest. In addition, it would report what the habitats are used for (e.g., roosting, foraging, nesting) by individual species of interest. It should also describe how and when water is applied to the crops, as this is a primary determinant of avian use patterns. Ideally, habitats that are most limiting to particular species would be identified. Although this may not always be known with a high level of certainty, it should still be articulated (and can treated as working hypotheses). At Staten, early season crane roost ponds are thought to be a limiting habitat type for cranes, and this influences planting and harvest scheduling.

Of all the different habitats that could potentially be provided to support wildlife at Staten, we need to determine which are the most important given limitations regionally. In particular, more research is needed to determine the extent to which Staten provides habitat for shorebirds. Given their small size and cryptic coloration, shorebirds may be more difficult to detect during surveys than other guilds of birds. Although shorebirds don't appear to use flooded corn fields very much—instead preferring bare mud—they are commonly observed in the fields and roost ponds when water is drawn down.

Given that the majority (87% in 2010) of Staten is planted as corn, it is worth reviewing the research needs that have been identified for avian use of this crop type. Taft and Elphick (2007) provided a review of the literature on this subject and identified a set of outstanding research needs. Although their focus was on bird use of corn, much of what was presented was drawn from research conducted outside of California (in the mid-western US). Even so, many of the research needs identified are relevant to this region. The most compelling of these are introduced below. Some of the text is taken directly from Taft and Elphick (2007).

- There is a need to estimate the cumulative use of corn fields by certain species that are widespread in their use, but which occur in small numbers in any particular field (e.g., Shorebirds). This would provide a landscape perspective on the overall importance of cornfield habitats. Also, it would be valuable to know how much corm acreage in the Delta currently is being flooded and how much that is not flooded might be suitable for that purpose. Then if data on shorebird densities were obtained for corn, some overall estimate of Delta-wide shorebird use could be made.

- Uncertainty remains regarding how a continued increase in harvest efficiency may affect waterbird populations. Additional studies are needed that document the waste grain densities at which foraging birds abandon fields (the "giving-up density"), or that link the abundance of waste corn to waterbird body condition, survival and/or reproductive success. Dugger's study, introduced above, will provide some information on this.

- It would be valuable to track the population trends and landscape use of cranes but also other numerous waterbirds that overlap strongly in their foraging needs. This would provide information on whether, for example, the increasing population of Aleutian Cackling Geese in the Delta is having any impact on food availability for cranes.

- Better quantification is needed of terrestrial invertebrate resources such as pest insects, earthworms and arthropods in corn fields and their consumption both by breeding species and nonbreeders (especially shorebirds).

- To evaluate the overall impact of genetically modified corn on waterbirds (and the widespread use of glyphosate herbicides), we need to improve our understanding of the relative importance of weed plant resources (seeds, new shoots) and associated terrestrial invertebrates as foraging resources for waterbirds. Moreover, further work in this area would allow us to better assess the role that waterbirds can play in biological control, and thus the potential to lessen the dependence on chemical use.

- For those species documented as nesting in corn fields, there is little published information on their breeding success. Documentation of nesting success in corn fields and postnesting habitat use by young birds would further our understanding of the overall importance of cornfield nesting resources to waterbirds. Studies of particular value would include assessing how nest success relates to increased residues in no-till fields, and patterns (e.g., timing, number of field passes) of in-field machinery use. Comparisons of nesting productivity in corn fields to other natural and agricultural habitats are also needed.

- Continued research is needed on the impacts of alternatives to heavy pesticide use, including use of low toxicity chemicals, planting of GM corn, and crop management practices (organic farming, biological control) on waterbirds and cornfield food resources. In particular, parsing out the organic farming practices that benefit high priority waterbird species would help identify aspects of organic farming that could potentially be incorporated into conventional farming.

- For all corn-growing regions and Bird Conservation Regions, a greater understanding of the influence of landscape factors (e.g., proximity to natural marsh habiats) on waterbird use of corn fields should enable more strategic broad-scale approaches to conservation planning in agricultural landscapes. Landscape studies should include all crop types and natural habitat types used by waterbirds, and the various features of these used by waterbirds (roost sites, nesting marshes or trees, etc.). Information of this sort is critical for determining the optimal mixes and distributions of habitats and crop types.

- Finally, investigating the trade-offs between the benefits and costs of various corn farming methods to the conservation of waterbirds and the economics of corn production will be a vital focus for future research, enabling the ultimate design of sustainable conservation-oriented agronomic practices.

Non-bird Research Needs

Additional research topics follow from the above discussions included in the sections entitled "*Site-specific Management Considerations*" and "*Potential Future Conditions*". These are not further developed in this section, but include topics such as: What land use types (including croplands and natural habitats) are best from the standpoint of carbon sequestration, or reversal of subsidence?

Additional information needs at Staten include better assessing the condition of the levees, ascertaining past and current rates of subsidence, and determining how deep the peat soil is on the island.

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