Landscape influences on heron and egret colony site selection, nest productivity, and foraging distribution in the San Francisco Estuary

Integrated Regional Wetlands Monitoring (IRWM) Project

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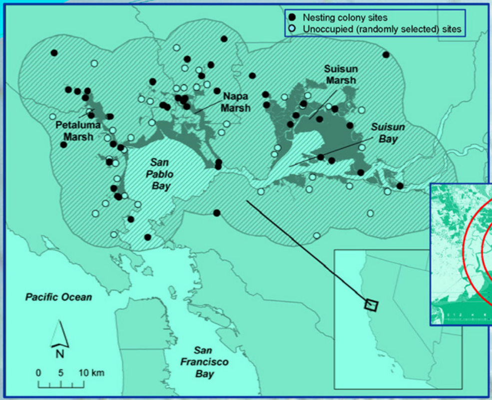
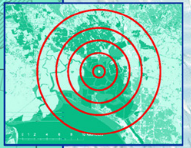




INTRODUCTION

We measured the size of nesting colonies and nestling productivity in successful Great Blue Heron (*Ardea herodias*) and Great Egret (*Ardea alba*) nests at 45 heronries known to be active (1991-2005) within 10 km of historic tidal marsh of San Pablo Bay and Suisun Bay. We analyzed the results with regard to landscape associations within 1, 3, 5, 7, and 10 km of heronries (see figure above right), based on NOAA land cover types and several wetland-patch metrics (FRAGSTATS).

To evaluate regional implications, we generated predictive maps of landscape quality with regard to colony site selection and the productivity of successful nests. To determine if the availability of suitable feeding and nesting areas was consistent with predicted space use by foraging Great Egrets, we modeled the distribution of flight distances from heronries and used the results to predict foraging distribution across northern San Francisco Bay wetlands.

METHODS

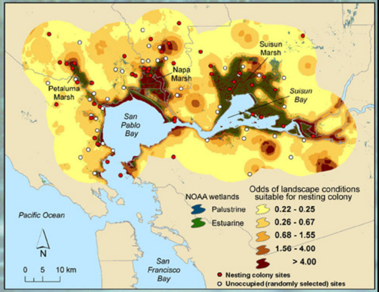
We visited most heronries at least four times each nesting season, 1991-2005. Counts of active nests and brood sizes were made from the ground or from boats, often by trained volunteer field observers.

Herons and egrets typically reduce the sizes of their broods through asynchronous incubation and hatching which leads to a hierarchy of competitiveness and survivorship among nestlings. One likely benefit of brood reduction is an ability to match reproductive effort to unpredicted changes in prey availability or wetland productivity. Most brood reduction occurs within four weeks after hatching. Therefore, to investigate relationships between heron and egret productivity and landscape foraging conditions, we evaluated the sizes of broods when nestlings were 5-8 weeks old.

We used aircraft to track Great Egrets departing from heronries and used the observed flight distances, colony sizes, and distribution of wetland habitat to model regional foraging densities.

Land cover predictors of occupied ($n = 44$) vs. unoccupied (random, $n = 44$) colony sites, based on model-averaged results from the top four logistic regression models (difference in Akaike's Information Criterion for small samples, $\Delta AIC_c < 7$; likelihood ratio χ^2 significant in all models, $P < 0.001$). Scale indicates the radius within which each variable was measured. Relative importance of predictors is indicted by the sum of the relative AIC_c weights (Σw_i).

Predictors variable	Scale (km)	Model-averaged coefficient	Odds ratio	Relative importance (Σw_i)
Estuarine emergent (km²)	1	1.65	5.23	0.98
Open water (km²)	1	1.18	3.27	0.97
Bare land (ha)	3	0.04	1.05	0.74
Bare land (ha)	1	0.28	1.33	0.26
Estuarine emergent (km²)	3	0.12	1.13	0.02
Open water (km²)	3	0.14	1.15	0.03



COLONY SITE SELECTION

A comparison of landscape characteristics surrounding active heronries and randomly selected, unoccupied sites revealed the primary importance of estuarine emergent wetland and open water within 1 km.

The predicted probabilities of colony site use across the study area suggested that landscape conditions associated with active heronries were more likely near the shoreline of San Francisco Bay and in the central portions of major tidal marsh areas, especially Napa and Suisun Marshes. The establishment of colony sites based on local conditions, the consistent use of colony sites across years, and the predominance of foraging flights terminating within localized areas (see panel on right) and suggest the long-term importance of nearby feeding habitat.

PRODUCTIVITY OF SUCCESSFUL NESTS

Predictors of prefledging brood size in Great Blue Herons suggested significant influences within 1-3 km of heronries (see results below). The negative effect of cultivated land on the productivity of Great Blue Heron nests was associated with vineyards, cropland, and orchards in upland areas that may be unsuitable for foraging herons. Because the effect of cultivated land is inversely correlated with open water, reduced nest productivity at sites surrounded by cultivated land may partly reflect a decline in the extent of open-water.

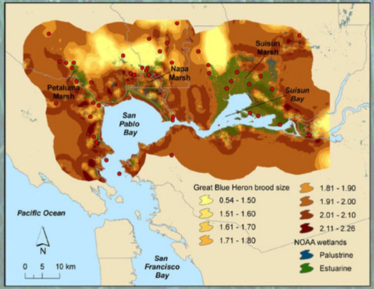
The number of young fledged in successful Great Egret nests was influenced by larger scales of habitat variation. Significantly more young were produced in successful nests at sites with less open water within 10 km, more estuarine emergent wetland within 10 km, and more low-intensity development within 7 km. In contrast to the positive effect of open water on the productivity of Great Blue Heron nests, the extent of open water was inversely related to the number of young in successful Great Egret nests. This difference was consistent with the positive effect of emergent vegetation on Great Egret productivity, as well as preferred use of small ponds by foraging Great Egrets and larger bodies of water by Great Blue Herons. The positive effect of low-intensity development suggested an association with small ponds, ditches, and manipulated water sources.

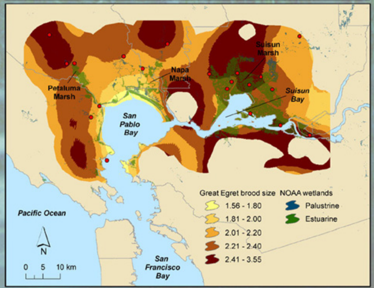
Predictive maps of nest productivity (below) reflected the smaller scale of landscape variation associated with Great Blue Heron nests compared to Great Egret nests. The map for Great Blue Herons suggested that colonies are likely to be more productive near the borders of major wetland areas and less productive in the centers of wetland areas and on upland hillsides. The map for Great Egrets reflected the larger scale of landscape influences, with the greatest nest productivity predicted in Suisun Marsh and areas with low-intensity development near wetlands. Relatively low Great Egret nest productivity was predicted in northern San Pablo Bay marshes.

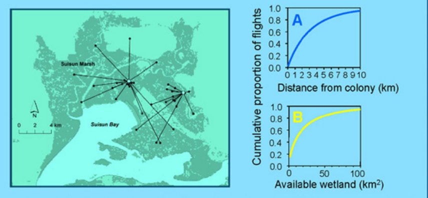
Landscape predictors of mean brood size in successful Great Blue Heron and Great Egret nests, based on model-averaged results from the top four multiple regression models (difference in Akaike's Information Criterion adjusted for small samples, $\Delta AIC_c < 7$; $R^2 = 0.56$-0.94). Scale indicates the radius within which each variable was measured. Relative importance of predictors is indicted by the sum of the relative AIC_c weights (Σw_i).

Predictors variables	Scale (km)	Model-averaged standardized coefficient	Σw_i
Great Blue Heron			
Cultivated (km²)	3	-0.81	1.00
N wetland patches[a]	1	-0.47	0.91
N wetland patches[a]	3	0.44	0.91
Open water (km²)	1	0.18	0.04
Open water (km²)	7	0.18	0.04
Open water (km²)	10	0.18	0.02
Great Egret			
Open water (km²)	10	-0.74	1.00
Low-intensity development (km²)	7	0.69	0.97
Estuarine emergent (km²)	10	1.10	0.84
Wetland edge (m)[a]	10	0.99	0.16
N wetland patches[a]	10	-0.26	0.11
Low-intensity development (km²)	3	0.47	0.03

[a]estuarine-emergent wetland





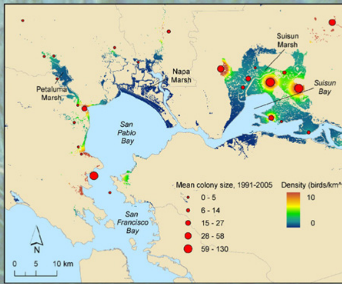


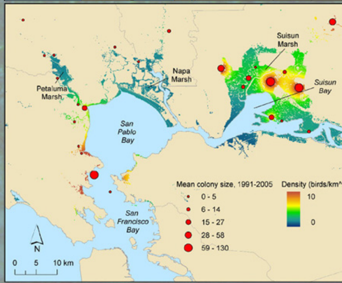
Estimated cumulative foraging dispersion of Great Egrets, based on 1000 bootstrap samples of departure flights (n = 36) from heronries in Suisun Marsh, as a function of (A) flight distance and (B) extent of wetland accessible within flight distances.

FORAGING DISPERSION

Predictive maps suggested concentrated areas of foraging by Great Egrets near heronries, separated by larger areas with relatively low foraging pressure. The wetland availability model (bottom map) predicted a more even regional foraging distribution than the distance model (top map) but the predicted densities were still substantially concentrated near heronries.

Predicted foraging densities were highest in Suisun Marsh, the lower Petaluma Marsh, and along the western shoreline of San Pablo Bay southward to the northern shoreline marshes of Central San Francisco Bay.





IMPLICATIONS FOR WETLAND RESTORATION

Our results suggest that the restoration of wetland foraging conditions for herons and egrets may (1) influence reproductive performance in heronries up to 10 km away, (2) lead to increased foraging by herons and egrets at sites within 10 km of heronries, especially within 3 km of heronries, and (3) increase nest abundance at heronries within 3 km of restoration sites. Regional planners could enhance the value of wetland landscapes to nesting herons and egrets by clustering habitat protection or restoration projects within a few to several km of colony sites.

We suggest prioritizing the restoration of potential nesting sites in locations that are farther from active heronries than the average regional distance between colony sites (approximately 6 km) and have landscape features associated with both higher reproductive performance and preferred colony sites. Such features include large areas of estuarine emergent wetland interspersed with open water channels and ponds to create a wetland patch matrix.

Background photo by Len Blumin