Wetland conservation and the health of heronries

The Protection of Nesting Landscapes

by John P. Kelly

If you stand for more than a few minutes near any wetland or shoreline in the San Francisco Bay area, you are likely to see a heron or egret winging quietly across the landscape—an encounter that reinforces one's sense of place. The length of time you must wait for such an occurrence, however, depends not only on your particular location but also on habitat conditions over a vast landscape.

The way herons and egrets interact with the geometry of the regional landscape is complex. If the routes of all nesting herons and egrets in our region could be tracked for one day, the resulting map would reveal dense traffic patterns like those of global airline routes, but with one difference: less than half of the flights would terminate at colony sites, where birds congregate, whereas all airline flights target busy airport terminals. Rather than resembling simple routes among airports, the flights of nesting herons and egrets reflect the complex interactions of "central-place foragers" that recurrently depart from nesting colonies to search for food among countless foraging destinations in the surrounding landscape. To succeed, they must optimize the amount of time and energy they spend on flight relative to a myriad of surrounding foraging opportunities. The most productive birds are those that achieve the greatest net energy gain as they search for, capture, and transport prey to feed their nestlings.

The considerable ecological and economic values of wetlands and increasing pressures of human land use have inspired continuing interest in how nesting herons and egrets are affected by the quality or extent of surrounding wetlands. As a partner in the
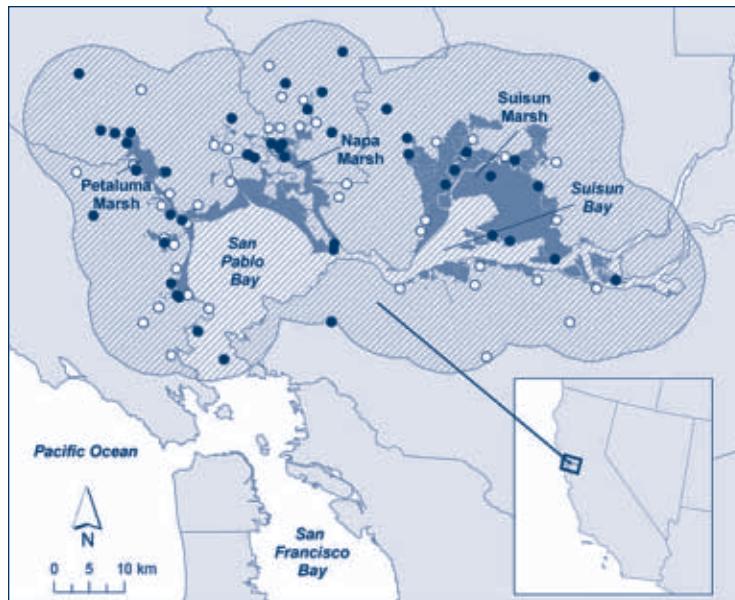

Figure 1. The study of landscape influences on nesting herons and egrets encompassed all areas within 10 km of all known heron and egret colony sites (1991–2005) within 10 km of the historic tidal marsh boundary of Suisun Bay and the Petaluma and Napa marshes of San Pablo Bay (diagonal hatching). Solid circles indicate heron and egret nesting colonies; open circles indicate randomly selected, unoccupied sites (see text).

Integrated Regional Wetland Monitoring project for the San Francisco Estuary (www.irwm.org), I worked with colleagues at ACR and PRBO Conservation Science on a study of heron and egret reproductive performance and colony site selection in relation to the proximity and extent of their wetland feeding areas (Kelly et al. 2008; Figure 1).

We quantified landscape values by measuring the extent of each habitat type within 1, 3, 5, 7, and 10 km (radii) of each colony site, based on land cover classification of satellite imagery (NOAA Landsat images, 2000–2002). We also counted the number of wetland patches within each distance, a metric associated with differences in hydrologic timing and receding water levels in isolated pools that concentrate prey. Finally, we measured the total length of wetland edge habitat within each distance around heronries.

One way to determine the value of surrounding habitat to nesting herons and egrets is to estimate the extent to which habitat conditions influence the number of young they can fledge. The productivity of heron and egret nests depends in part on whether they survive the risks of nest predation, human disturbance, and extreme weather events. Nest attempts that are affected by such dangers usually end in complete failure. In contrast, the productivity of successful nests depends on the extent of "brood reduction," which reduces the number of surviving young. This is a consequence of asynchronous incubation and hatching, which leads to a size hierarchy of competitiveness and survivorship among nestlings. Brood reduction allows herons and egrets to quickly adjust the number of young they must feed in response to changes in the supply or availability of food. Therefore, the number of young fledged from successful nests should be sensitive to the availability of suitable foraging habitat around heronries.

We used the habitat measurements described above and results from our continuing study of heronries in the northern San Francisco Bay region (Kelly et al. 2007) to investigate two types of landscape effects on nesting herons and egrets. First, we examined how landscapes influence heron and egret colony site preference. To do this, we compared habitat conditions surrounding 44 occupied colony sites with those surrounding 44 randomly selected, unoccupied sites with similar site characteristics and proximity to the tidal marsh boundary. Second, we evaluated how landscape
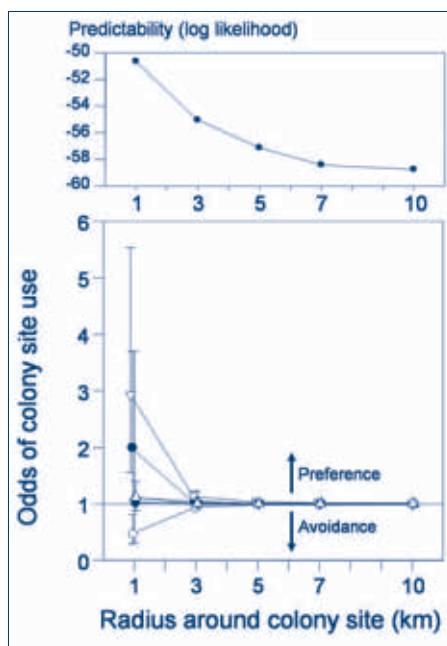
Figure 2. Heron and egret colony site preference was more predictable when habitats were measured within 1 km of sites (top figure; logistic regression). Surrounding habitats affected the odds of colony site use more dramatically at distances of less than 1 km (bottom figure; 95% confidence intervals). Symbols indicate estuarine emergent wetland (●), open water (▽), low intensity development (▲), grassland (⊕), number of wetland patches (△), palustrine emergent wetland (▼), and total wetland edge (✖).

quality affects heron and egret reproductive performance.

Each of the two investigations involved several combinations of habitat variables that were repeated within each of the five spatial scales of measurement around heronries, resulting in numerous statistical models. Because foraging Great Blue Herons *(Ardea herodias)* and Great Egrets *(Ardea alba)* may fly farther than 10 km to feed, we expected that models based on habitats measured within the largest radius (10 km) around colony sites would be the most effective in predicting colony site preferences and reproductive performance.

Colony site preference

Predictions of colony site preference between occupied vs. unoccupied (randomly selected) colony sites revealed the primary importance of estuarine emergent wetland and open water within 1 km (Figure 2). The odds of landscape conditions being suitable for a colony site increased by a factor of nearly three with each additional km^2 of open water and by a factor of two for each km^2 of estuarine emergent wetland within

1 km, but decreased by a half with each km^2 of grassland within 1 km.

In an interesting application of the analysis, we generated regional maps that predict conservation values across the wetlands of northern San Francisco Bay (based on a 100-m resolution grid). The predictions suggested that landscape conditions suitable for colony sites were more likely in areas immediately adjacent to the shoreline of San Francisco Bay, near the upper (eastern) end of the estuary, and in the central portions of major tidal marsh areas, especially Napa and Suisun Marshes (Figure 3).

Productive landscapes

Nest productivity in both Great Blue Herons and Great Egrets was sensitive to the extents of surrounding estuarine emergent wetland, open water, and low-intensity development, with Great Blue Herons producing fewer young at colonies surrounded by more grassland (Figures 4 and 5). We discovered that a greater extent of open water around colony sites was associated with increased productivity in Great Blue Heron nests but with reduced productivity in Great Egret nests (Figures 4 and 5). This difference is consistent with the preference of Great Egrets for small ponds and estuarine emergent vegetation, whereas Great Blue Herons often choose larger bodies of water (Custer and Galli 2002), are less sensitive to water depth (Gawlik 2002), and generally capture larger prey. The positive effect of low-intensity development on productivity in both species suggested the value of small, undetected ponds, ditches, and other manipulated water sources, although we have not verified this possibility.

The number of young fledged from successful Great Blue Heron nests was influenced equally by habitat conditions measured within all spatial extents around colony sites, but was not particularly sensitive to conditions at any particular landscape scale (R^2 ≤ 0.22; Figure 4). This lack of dominant habitat effects at any spatial scale is consisted with reports of individual Great Blue

Herons consistently using different feeding areas at different distances from the colony (Dowd and Flake 1985). Thus, Great Blue Heron colonies may depend on landscapes that provide suitable foraging habitat at all scales. In contrast, the number of young produced by Great Egrets was most sensitive to the total amount of habitat within 10 km of heronries (with positive and negative influences) and less sensitive to conditions within 1 km (Figure 5).

Predictive maps that illustrate the overall results of the analysis indicate the expected reproductive performance of herons and egrets at any point in the landscape (if a suitable colony site was established). The map for Great Blue Herons suggested higher nest productivity near bay shorelines and wetland areas (Figure 6). The map for Great Egrets predicted the highest nest productivity in the vicinity of Suisun Marsh and in areas with low-intensity development near to wetlands, and relatively low productivity in northern San Pablo Bay marshes (Figure 6).

Our results suggest that the reproductive activities of these key wetland predators depend on, and might affect, elements and processes in the tidal landscape within distances of 10 km or more. The predatory activities of herons and egrets within this distance might affect the populations or behavior of their prey or the activities of other wetland predators. In addition, concentrations of guano, discarded food, and fallen nestlings under heronries may have localized effects on nutrient cycles in marshes.
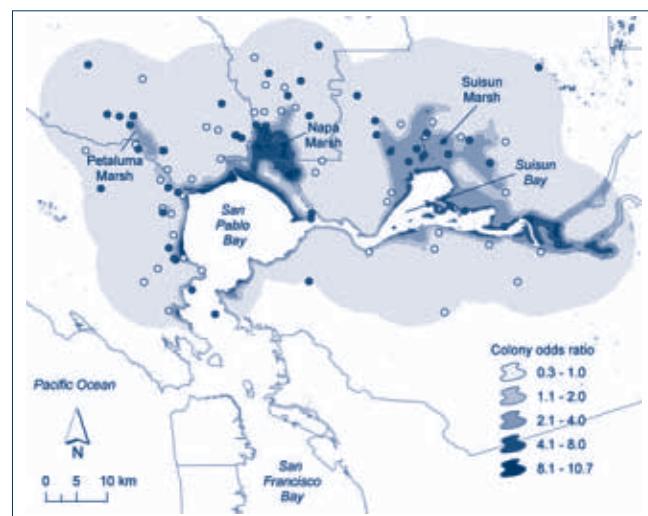

Figure 3. Odds of colony site use by herons and egrets relative to landscape conditions in northern San Francisco Bay, based on logistic regression of actual colony sites (1991–2005; solid circles) vs. randomly selected, unoccupied sites (open circles). Low odds of site use in areas surrounding wetlands contrast with the presence of several small Great Blue Heron colonies because the analysis focued on conditions suitable for mixed-species colonies.
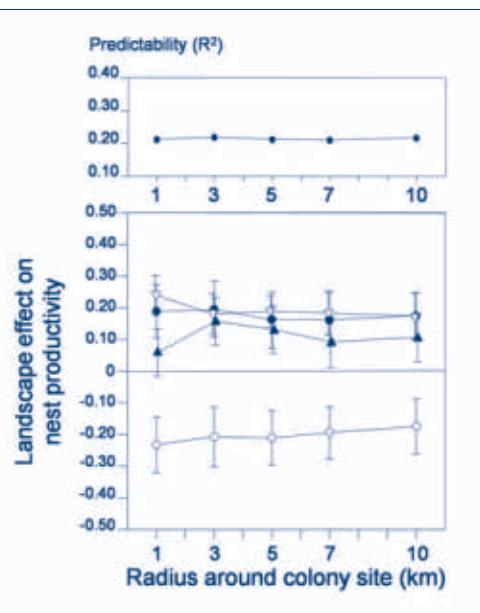
Figure 4. The number of young produced in successful Great Blue Heron nests was equally predictable at all spatial scales of habitat measurement around colonies (top figure). Great Blue Heron nests produced more young when surrounded by more estuarine emergent wetland (●), more open water (▽), more low intensity development (▲), and less grassland (⊕; standardized regression coefficients ± standard error).
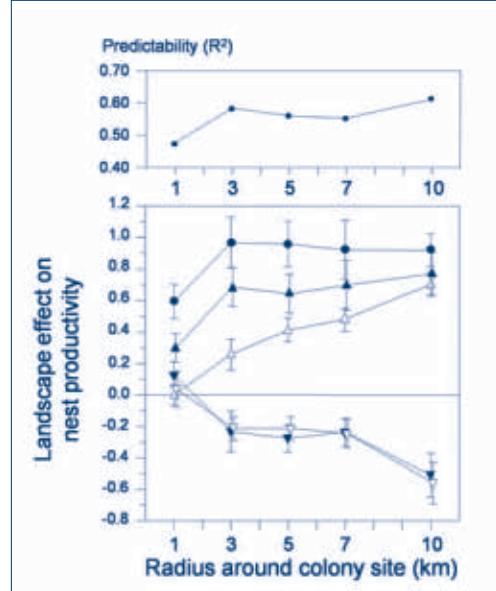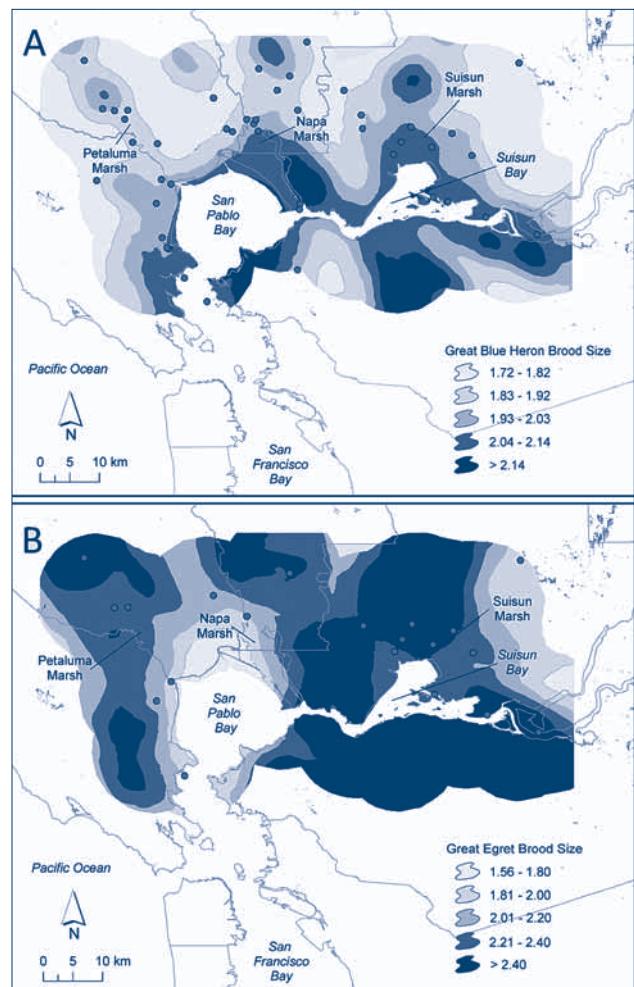

Figure 5. The number of young produced in successful Great Egret nests was more predictable at greater spatial scales of habitat measurement around colonies (top figure). Great Egret nests produced more young when surrounded by more estuarine emergent wetland (●), more low intensity development (▲), more wetland habitat patches (△), but less open water (▽) and less palustrine emergent wetland (▼)—especially when measured within 10 km (standardized regression coefficients ± standard error).

Figure 6 (at right).
The predicted number of young produced in successful nests of (A) Great Blue Herons and (B) Great Egrets, based on landscape influences in northern San Francisco Bay, 1991–2005. Solid circles indicate colony sites.

The broad influence of landscape habitat conditions on herons and egrets emphasizes the importance of regional wetland management and collaborative planning. Our results suggest that regional planners may be able to enhance the value of wetland landscapes to nesting herons and egrets by promoting clusters of habitat protection or restoration projects within a few to several km of colony sites. We have recommended that regional planners prioritize wetland habitat protection and restoration in locations that have landscape features consistent with heron and egret colony sites preferences and higher reproductive performance. Such features include more extensive areas of emergent wetland interspersed with open water channels and ponds, within 1 km and 10 km. Similar criteria should be used to create or protect viable landscapes around existing colony sites.

Acknowledgements

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