Conservation Science and
Habitat Protection at
Audubon Canyon Ranch

THE ARDEID

Brian E. Small / VIREO

◗ coastal prairie

grassland research

◗ nesting landscapes

wetland conservation

◗ bit by byte

long-term monitoring

◗ ACR action

science-based

conservation

2008

In this issue

***Cover:** Grasshopper Sparrow, a denizen of California coastal prairie grasslands. Photo by Brian E. Small /VIREO*
Ardeid *masthead Great Blue Heron ink wash painting by Claudia Chapline.*

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Grassland research at ACR's Toms Point

Conserving and Restoring California Coastal Prairie Grasslands

by Jeffrey D. Corbin

JEFFREY D. CORBIN

Figure 1. Grassland study area at Toms Point, Tomales Bay.

Even though I am a California native who grew up hiking hillsides near San Francisco Bay, it wasn't until my 20's that I realized that most of the plants in my favorite hiking spots are "out of place." The dominant species in almost any grassland habitat arrived in our state only in the last 100–200 years. Wild oats: not native to California. Fennel: not native to California. Mustard: not native to California. These now-ubiquitous invasive species evolved elsewhere—usually in another Mediterranean climate region such as Europe or South Africa—and found an appropriate habitat here once they were introduced.

I now understand the impacts of the "new" arrivals on the ecology of California habitats. The golden hills that most of us associate with summer-time vistas are a very different landscape than the one that greeted the earliest European settlers. California's grassland ecosystems were once largely dominated by native perennial bunchgrasses that live for more than 100 years and grow deep root systems so that they can survive our annual summer drought. Today, our native flora—the plants that evolved here and are a key part of the region's biodiversity—are much less widespread and usually a minor component of the grassland ecosystem.

The conversion of grasslands from habitats dominated by native California plants to areas covered predominantly by short-lived annual plants have had dramatic effects on the ecology of grasslands and other habitat types in California. These areas used to support much more diverse native plant and animal communities than those we see today. The stunning wildflower displays that we enjoy in the spring are a legacy of the native grasslands, and invasive species have decreased native plant species in many habitats. The shift from native perennial grasses to exotic annual grasses has also had cascading effects on the animals that depend on the perennial plants as food sources in the summer.

Today, we recognize the value of our native species and the impacts that the new arrivals have had on our environment to a much greater extent than we did just a few years ago. Ecologists who manage grassland habitats, including the staff of Audubon Canyon Ranch (ACR), are applying best-management practices to reduce the spread and impacts of the invasive species and to reintroduce native species to areas from which they have been extirpated.

I have been lucky enough to spend the last 10 years studying the ecological interactions between the native and non-native plants in coastal grasslands and testing specific techniques that will help restore native biodiversity. Much of this work has taken place at ACR's Toms Point Preserve near the northern end of Tomales Bay (Figure 1). The unique combination of a protected grassland and the possibility of experimentation provided by ACR's mission to encourage scientific research on its lands has contributed greatly to the range of questions that I have been able to pursue during this time. Let me also add that the support of ACR staff, especially Dr. John Kelly, made much of this work possible.

Can native species compete with non-native species?

Plants living in the same habitat compete with each other for the same general resources required for growth and survival—space to germinate and grow, light, water, and soil nutrients, among others. The presence of non-native species—especially the annual grasses such as wild oats (*Avena* spp.) and ripgut brome *(Bromus diandrus)*—likely reduces the ability of native grasses to survive when the non-natives are abundant, and it complicates efforts to reintroduce native species.

I conducted several experiments at Toms Point that tested the competitive interactions between native bunchgrasses and non-native grasses. Along with my colleague Carla D'Antonio, I established experimental field plots comprised of one of three treatments: native grasses only, exotic annual grasses, or both groups together. By comparing the growth and survival of the native species in plots with and without non-native competitors, we were able to measure the effect that the exotic annual grasses had on the populations of native perennial grasses. We could also make the same comparisons for the non-native species by comparing their growth in plots without the native competitors versus plots with native competitors. We expected that the exotic annual species would be the superior competitors, and that they would reduce the growth of the native species.

The results were somewhat unexpected, however, in a very encouraging way. In the first year, competitive interactions favored the invaders: the growth of the native grasses grown with the exotic annual grasses was two-to-three times less than grasses grown without the exotic annual grasses. However, in the subsequent three years, the native grasses reduced the productivity of the exotic annual grasses (Figure 2)! By the fourth year of the experiment, native grasses reduced the growth of the exotic annual grasses by a factor of five, while the native grasses grown with the exotic grasses grew nearly as well as in plots without the exotic competitors.

Why did this happen? How were the native grasses able to have such a significant effect on the growth of the non-native species? The key to this question lies in an important difference between the native bunchgrasses found in coastal grasslands such as Toms Point and the exotic annual grasses. As I mentioned earlier, the native bunchgrasses are long-lived and begin each growing season with an established base and root system. By contrast, the exotic annual grasses complete their entire life cycle in a single growing season, germinating in the late fall with the first rains and producing seeds for the next generation by the beginning of the summer drought. This means that an established population of native bunchgrasses begins each growing season with an advantage over the exotic annual grasses, which must "start over" each season with no established population. To use an analogy from politics, I like to think of the established bunchgrasses as the "incumbents" in the system—their established base and root systems ("grassroots"?) are able to reduce the access of the exotic annual grasses to soil, light, and other resources that all plants need.

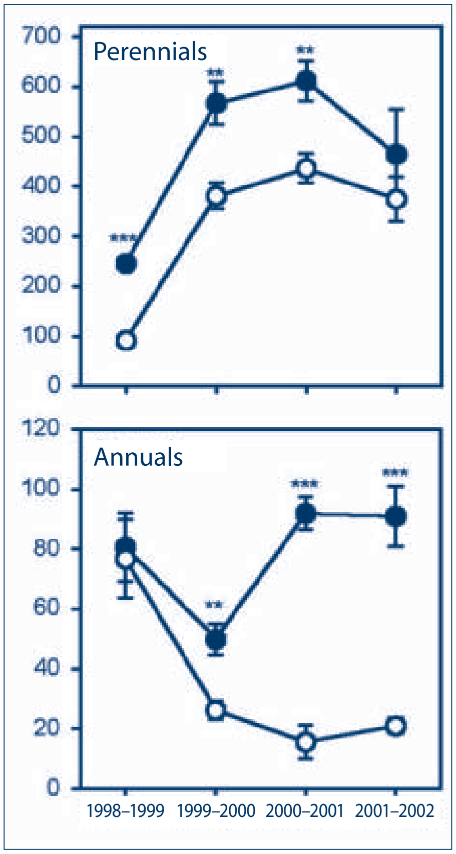


Figure 2. Mean productivity (g/m^2 ± 1 SE) of native perennial bunchgrasses (top figure) and exotic annual grasses (bottom figure), with (○) and without (●) intergroup competitors. Asterisks (*) indicate significance between treatments in a given year.

This result is highly encouraging for efforts to restore native biodiversity in grassland habitats. It suggests that native species can compete with exotic annual grasses, and that habitats in which grasses have become established can persist. For those managing grasslands, including ACR's Toms Point and Bouverie Preserves, this means that effort spent restoring native grass populations is likely to pay off in the form of stable native communities that can persist in the face of future invasions.

Given that established native perennial grasses can be strongly competitive and are capable of suppressing exotic annual grasses, the question remains as to how exotic annuals have been able to maintain their dominance in many California grasslands. Unfortunately, few descriptions exist of the ecology of the region during the early settlement by Europeans, and so we do not have a good picture as to what the community composition was like or how the conversion to exotic dominance took place. Our best guess is that the exotic annual grasses and other non-native species benefited from new activities that came with European settlement, including intense grazing and land-clearing.

These results suggest that both native perennial grasses and exotic annual grasses can form stable, long-lived communities if given the chance to become established. In other ecological terms, the native and non-native communities are "alternative stable states" and it takes significant input from outside sources—such as changes in land use in the past, or active restoration in the present—to alter the current dominant state.

How can we increase native establishment and restore native biodiversity?

If established native bunchgrass communities are stable and able to resist subsequent invasion, then the goal for restoration scientists is simple: maximize establishment of native populations. The challenge is that the barriers to successful establishment remain daunting. Chief among the barriers to native restoration are the low supply of native seeds reaching appropriate habitats and the intense competitive environment that newly germinating native seedlings must endure. While the naturally low supply of native seeds can be overcome through manual augmentation of seed input (e.g., through the commercial production of native seed), adding seeds alone is unlikely to be sufficient. Native seeds that germinate in exotic-dominated habitats are forced to compete with dense stands (>10,000 individuals per m^2) of exotic grass seeds that tend to germinate and grow more quickly than native species. The highly competitive exotic annual seedlings have been shown to suppress the growth of native bunchgrasses enough that natives are unable to develop the deep root systems necessary to survive California's summer drought.

The most promising strategy for increasing native components in invaded ecosystems is likely to be the coordination of multiple strategies that address exotic species abundance, native seed or seedling availability, and the competitive environment that the non-native species create. I applied such a combination of strategies in an attempt to restore populations in two grasslands—at Toms Point Preserve and in the Point Reyes National Seashore—dominated by non-native species. One comparison was to see whether the augmentation of natural seed supply could increase the establishment of native seedlings. The second was to reduce the above-ground competitiveness of the

JEFFREY D. CORBIN

Figure 3. The view looking northward from native coastal prairie at Toms Point.

non-native species by mowing plots to reduce the height and biomass of the community. The third was to reduce plant growth (of natives and especially the non-natives) by reducing soil nitrogen levels. I also tested two combinations of treatments: seed addition and mowing together, and seed addition and reduced soil nitrogen together.

The results after two growing seasons offered a sobering picture of the challenges that native seeds must face to become established in exotic-dominated habitats. Only one of the target native species, California brome *(Bromus carinatus)* successfully established in any of the treatments. Of the treatments designed to increase the rate of establishment, only mowing had a significantly positive effect on California brome. Neither the addition of native seeds nor the reduction of soil nitrogen increased the rate of establishment of any of the native species. In addition, there were no interactions between the treatments that would suggest that a combination of strategies that I applied would work better than one.

These results confirm studies by other scientists that the addition of seeds by itself is not enough to increase native establishment. Unfortunately, however, the combination of treatments that I selected was insufficient to overcome the intense competitiveness of the non-native species —at least through two growing seasons. The treatments were applied through a third growing season, and we are currently analyzing the results to see whether the effects were different in 2007–2008.

The future of restoration in California

California's grasslands will never revert back to the native-only conditions that the early European settlers saw. The non-native species that I described initially as "out of place" have been phenomenally successful here. They are found in almost every grassland in the state, and the proportion of the community comprised by the non-natives often approaches 100%. Furthermore, there are new invaders identified each year that have the potential to cause new shifts in community composition and change how the ecosystems function.

All is not lost, however. There are many successful strategies that can preserve native biodiversity in the state's grasslands while reducing the extent and impacts of non-native species. First, grasslands that already have a significant native component must be recognized as the treasures that they are. Such habitats should be given increased protection from development and other land-use activities that would either threaten native plant populations or create conditions that could encourage invasive species. Land-owners such as ACR who act as good stewards of the land are a critical part of this strategy. Second, we should focus on increasing native biodiversity in grasslands through such activities as seed and seedling addition, careful management of grazing and fire, and exotic species management. We should not only increase the abundance of natives where they have persisted, but also reintroduce them into places where they have been lost. Third, federal and state agencies must coordinate to reduce the introduction of new invasive species into the state that could cause further impacts in the future. Currently, legislation gives agencies few teeth with which they can prevent further introductions. There are even arms of the Department of Agriculture that fund projects to plant invasive plants that other arms of the USDA try to eradicate.

There is much to appreciate in our grasslands, even if they differ dramatically from what they looked like 200 years ago. Hike and enjoy one of the most beautiful ecosystems in the world. Some of the closest approximations of the pre-European grasslands can be found at Bouverie Preserve and sites along the coast such as Point Reyes and Toms Point (Figure 3). You can also join the California Native Grasslands Association (www.cnga.org) or the California Invasive Plant Council (www.cal-ipc.org) to help support efforts to conserve and restore the state's native grassland flora. For further reading, I suggest *California Grasslands: Ecology and Management* (UC Press), which I recently co-edited with Mark Stromberg and Carla D'Antonio.

Dr. Jeffrey D. Corbin is an Assistant Professor of Biological Sciences at Union College in Schenectady, NY. During several of his years of work on Tomales Bay, he was Postdoctoral Fellow and Adjunct Professor at the University of California, Berkeley. Toms Point Preserve and the Tomales Bakery are high on the list of things he misses since leaving California.

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 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).

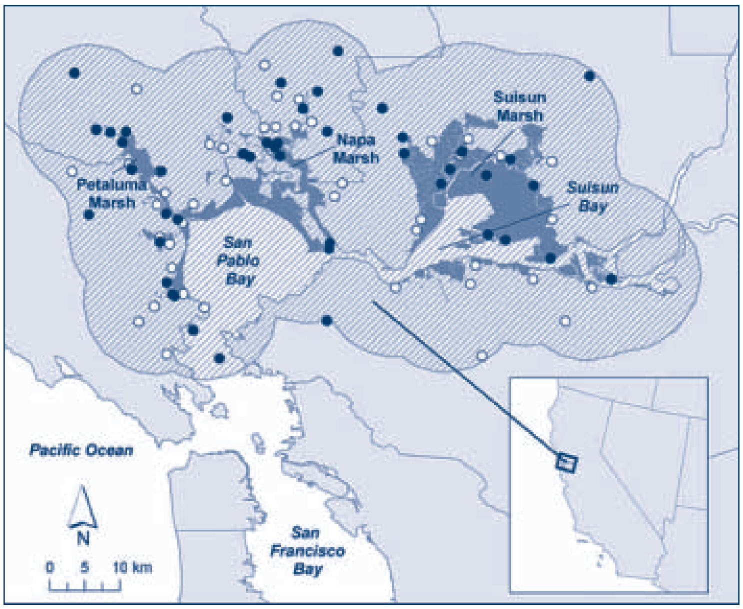


Figure 1. The study of landscape influences on nesting herons and egrets encompassed all areas within 10 km of all known heron and egret colony sites (1991–2005) within 10 km of the historic tidal marsh boundary of Suisun Bay and the Petaluma and Napa marshes of San Pablo Bay (diagonal hatching). Solid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

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

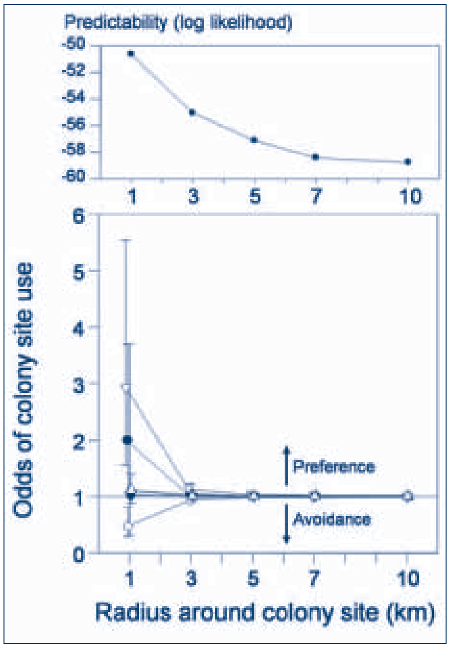


Figure 2. Heron and egret colony site preference was more predictable when habitats were measured within 1 km of sites (top figure; logistic regression). Surrounding habitats affected the odds of colony site use more dramatically at distances of less than 1 km (bottom figure; 95% confidence intervals). 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 ($R^2 \leq 0.22$; 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.

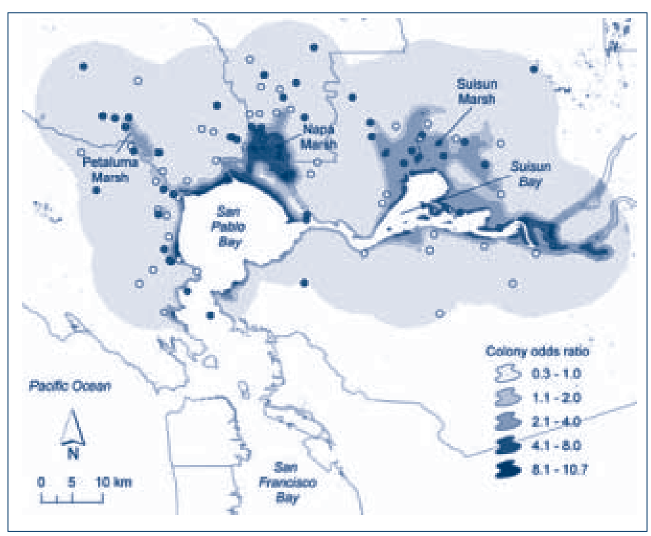


Figure 3. Odds of colony site use by herons and egrets relative to landscape conditions in northern San Francisco Bay, based on logistic regression of actual colony sites (1991–2005; solid circles) vs. randomly selected, unoccupied sites (open circles). Low odds of site use in areas surrounding wetlands contrast with the presence of several small Great Blue Heron colonies because the analysis focued on conditions suitable for mixed-species colonies.

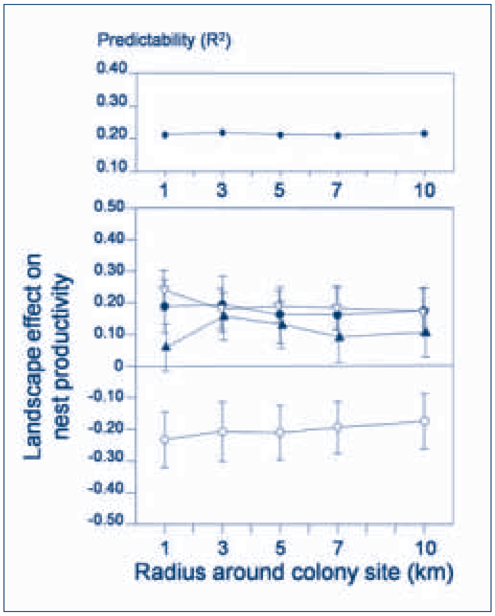


Figure 4. The number of young produced in successful Great Blue Heron nests was equally predictable at all spatial scales of habitat measurement around colonies (top figure). Great Blue Heron nests produced more young when surrounded by more estuarine emergent wetland (●), more open water (▽), more low intensity development (▲), and less grassland (⊕; standardized regression coefficients ± standard error).

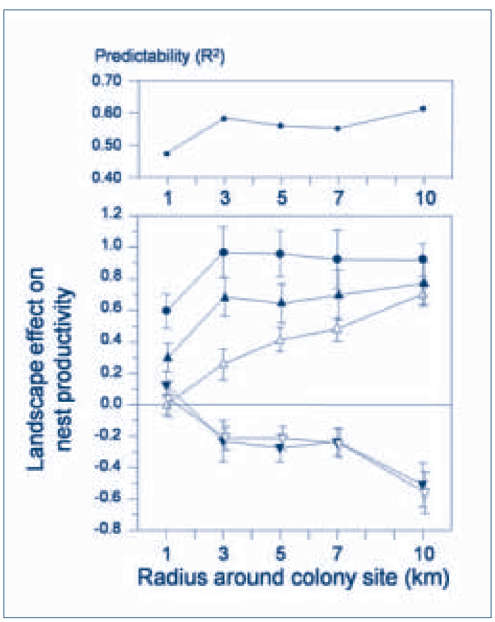
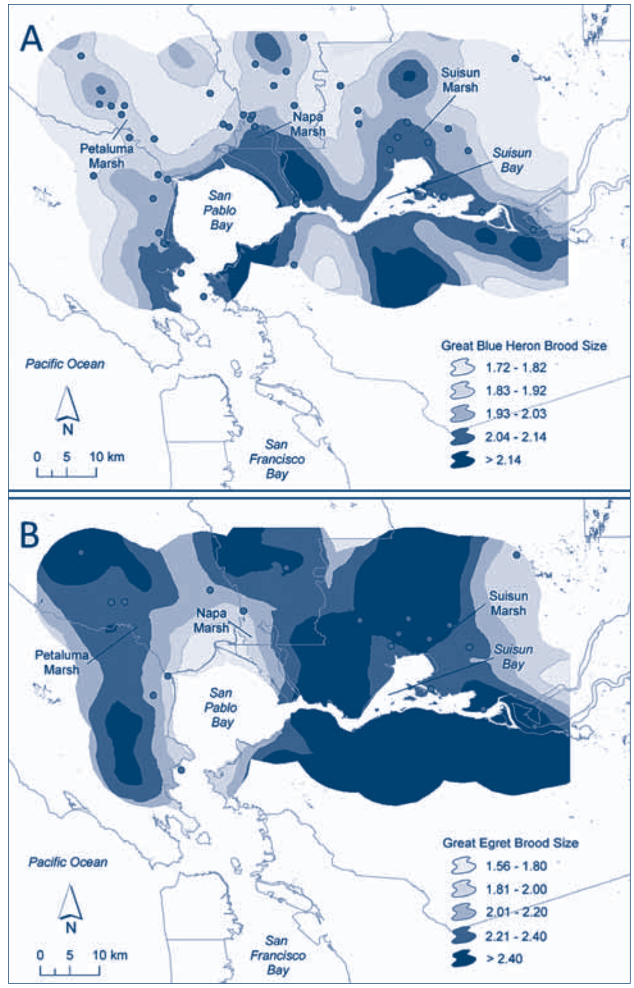


Figure 5. The number of young produced in successful Great Egret nests was more predictable at greater spatial scales of habitat measurement around colonies (top figure). Great Egret nests produced more young when surrounded by more estuarine emergent wetland (●), more low intensity development (▲), 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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The growth of ACR's long-term monitoring programs

Bit by Byte

by Emiko Condeso

Forty-one years ago, a graceful woman named Helen Pratt took her steadfast love of birds, naturally analytical mind, and infinite patience up the steep Kent Trail at Picher Canyon. Naturally, she didn't forget her spotting scope. Helen had begun documenting the reproductive activity of herons and egrets at the Bolinas Lagoon Preserve of Audubon Canyon Ranch, a project that would not only lead her to pen one of the most oft-cited scholarly publications on heron and egret natural history (Pratt 1970), but would also inspire a region-wide study of colonially nesting wading birds (Kelly et al 2007). Since Helen's retirement from fieldwork about ten years ago, the volunteers and staff biologists of Audubon Canyon Ranch have continued her twice weekly observations. Each year they capture another snapshot of breeding activity at this significant heronry, maintaining ACR's longest-running data set (Figure 1).

Helen's study at Picher Canyon is now one of several long-term monitoring projects conducted by ACR. Many groups, including agencies, non-governmental organizations, and universities, conduct long-term ecological monitoring. Such programs range from the continental scale of the National Science Foundation's Long Term Ecological Research (LTER) network to small organizations documenting single populations at specific locations. Monitoring is a core activity of conservation, for in order to identify potential threats and prioritize interventions, practitioners must have some way of assessing the status of what they are trying to protect (Marsh and Trenham 2008). As the influence of human activity on the natural world continues to increase, the need to make these assessments is becoming increasingly vital. Well-designed monitoring can provide insight into whether habitat is improving or degrading, if species abundances are increasing or decreasing, or if a management strategy is having the desired effect.

From heronry observations to newt counts, ACR's monitoring projects are as

CLERIN ZUMWALT

Helen Pratt monitoring the nesting activities of herons and egrets and Picher Canyon.

diverse as the preserves themselves. While the majority of these projects emerged from early explorations of the preserves and had primarily educational goals, the resulting archive of data is now a resource that can be used to address a variety of conservation questions. Analysis of data from the North Bay Heron and Egret Project, for example, has revealed significant shifts in colony size across the region in recent years, possibly related to ocean conditions, and the relatively long time scale of our data set may allow for investigation into the cause of these fluctuations (Kelly et al. 2007). In addition, the heronry data have been applied to the evaluation of restoration projects in the northern San Francisco Bay (www.irwm.org; Kelly at al. 2008) and have also been utilized by local agencies, planners, and consulting firms to evaluate the impacts of development. With other similarly rich data sets maintained by ACR, there are a number of relevant issues that may be addressed in future studies, from the extent to which the Pacific herring fishery in Tomales Bay impacts waterbird populations (see *Ardeid* 2007), to the influence of global warming on wintering Tomales Bay bird populations.

Audubon Canyon Ranch has made effective use of our monitoring data over the years by contributing to the peer-reviewed scientific literature and through direct conservation action (see article in this *Ardeid*), yet there are still additional ways these data can contribute to the conservation effort. As

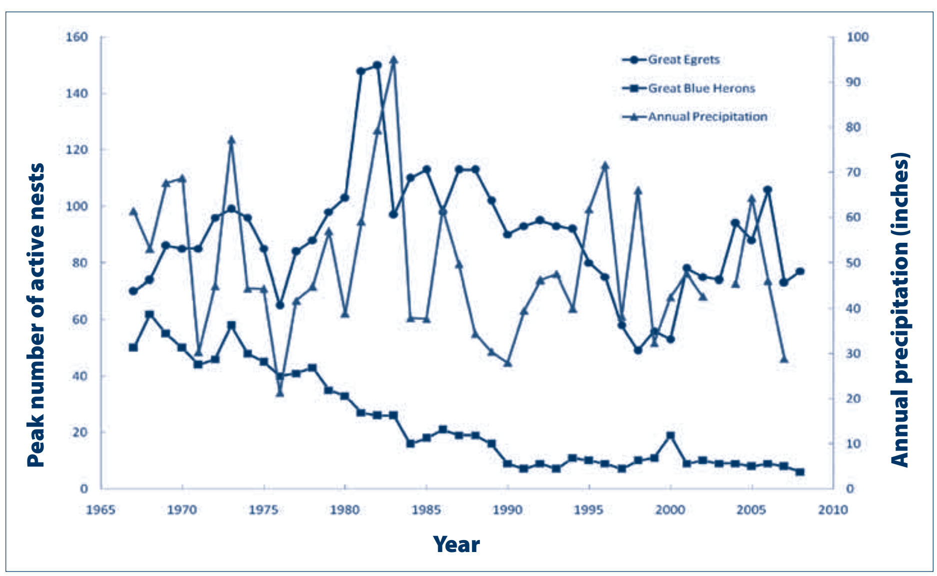

Figure 1. Peak number of Great Blue Heron and Great Egret nests at the Picher Canyon heronry, 1965–2008. Long-term patterns suggest a possible association between annual rainfall and the number of Great Egret nests, but underlying processes that might account for these patterns remain unclear. Rainfall data are from Kentfield, Marin County (National Climatic Data Center).

Sharing scientific information for conservation

Although researchers are often willing to provide access to data, sharing data effectively is surprisingly complicated. Great pains must be made to describe the purpose and meaning of every datum. Such meticulous documentation, or metadata, ensures that data are used and interpreted in an appropriate manner. Metadata comes in many flavors and, unfortunately, there is still no one standard accepted by all organizations and agencies. ACR metadata conforms to guidelines set by the Federal Geographic Data Committee (FGDC) for spatial data and the data report format recommended by the Ecological Society of America. Online data resources have become valuable in sharing ecological information (see examples below). Information about our projects is currently available through online resources such as the California Resources Evaluation System (CERES), and we are taking advantage of a variety of other new technologies to share our work with the conservation community. The geographic browser Google Earth has allowed us to communicate spatially referenced information with the conservation community about the network of heronries we monitor (www.egret.org/googleearth2.html). This has been an especially useful resource for those who do not have access to a geographic information system (GIS). We hope to continue to improve this resource by including other long-term monitoring efforts and by developing it into a true web-based GIS.

Examples of online data resources:

The National Biological Information Infrastructure (www.nbii.gov)
The Knowledge Network for Biocomplexity (knb.ecoinformatics.org/index.jsp)
The Avian Knowledge Network (http://www.avianknowledge.net)
California Resources Evaluation System (ceres.ca.gov)
California Avian Data Center (data.prbo.org/cadc2)
The San Francisco Bay Area Conservation Commons (northbaycommons.net)
The Bay Area Regional Database (bard.wr.usgs.gov)

the scientific community addresses complex issues at increasingly broader scales, shared access to the long-term data sets being collected across the world has become crucial. Conservation biologists have a responsibility to make the results of their studies available to the scientific community, and the gold standard for sharing research has always been peer-reviewed publication. That said, data sets that have not been published, especially the results of ongoing monitoring, may still have significant value and direct application to conservation. The peer-review process is also inherently slow, which may delay the application of results to management. Improvements in technology have removed many of the traditional impediments to long-distance collaborations, allowing researchers to share their work in new ways.

Organizations are emerging whose sole purpose is to connect individuals and groups with similar goals, from the expansive National Biological Information Infrastructure (www.nbii.gov) to our local San Francisco Bay Conservation Commons (www.northbaycommons.net). These groups are working to facilitate the synthesis of scientific information through the development of standards and technologies that simplify the integration and application of diverse resources. Data management responsibilities and philosophies are being defined that will promote sharing, ensure proper credit, and prevent misinterpretation of shared data. Some organizations elect to share project descriptions without the actual database—which also contributes to increased scientific collaboration and reduces redundancy. Becoming an active partner in such distributed networks is yet another way that long-term research at ACR is used, encouraging informed management and contributing to a clearer picture of the state of nature.

While brimming with potential, long-term monitoring projects are not without their challenges. Particularly relevant to non-profit organizations, cost is always a significant factor. Field biologists, equipment, data management, and analysis are all expensive. Long-term monitoring projects often lack a sense of urgency and may be considered expendable, especially in light of other more immediate issues. However if continuity is lost, so is a monitoring project's greatest asset: its consistency over time. One of the ways ACR meets these challenges is through the use of skilled volunteers. Years of experience, an investment in volunteer education, and project design focused on the needs of volunteers have contributed to the success of these efforts. We have developed field protocols specifically for volunteers, found ways to coordinate with many people across large geographic areas, and cultivated a group of individuals with high fidelity to our programs. We have also found significant additional benefits of working with volunteers. Engaging and educating the public often also contributes to the conservation effort. Many of our volunteers are community leaders, and some have grown to take on active roles in local issues. They have also become proud educators, bringing new people to our programs by sharing their enthusiasm for the work and the knowledge they have gained through volunteering.

As the ACR Conservation Science and Habitat Protection program evolves, so have our monitoring programs. Data resources at ACR are not only collected for our own needs, but also for the benefit of our conservation community. As such, our current monitoring efforts not only support the ACR research agenda but also facilitate the use of valuable environmental information by others working in our region and similar ecosystems. Helen Pratt produced a significant body of work and drew valuable insights from her observations at Picher Canyon, yet there is much to be gained by continuing her work and our other monitoring efforts.

Data collection is a significant investment in time and expense; therefore we strive to honor that investment and view our long-term data resources as dynamic, not static, collections. This challenge means that we must not only maintain our programs, but also evaluate them regularly with attention to current environmental concerns. How can we enhance the design of our monitoring projects to maximize their usefulness? What supplementary data sets could be easily collected and would provide useful information for visiting researchers and our own staff? By actively refining the way we manage and share long-term monitoring results, we are providing new and valuable information to the conservation community, documenting ecological context for our shorter-term investigations, and further enhancing the scientific value of our sanctuaries.

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Science-based conservation at Audubon Canyon Ranch

Implications, Influence, Action

by John P. Kelly

The critical role of conservation science today hinges on this fact: policy makers must deal with many competing issues whereas conservation scientists are best able to follow E. O. Wilson's (1994) advice, to "love the organisms for themselves, first...." This latter perspective accounts for the strength of Audubon Canyon Ranch's commitment to local and regional environmental action (Figure 1).

One of the most powerful forms of advocacy affecting conservation stakeholders is the promotion of "the best available science." Unfortunately, such efforts often fail to meet current conservation needs, because decision makers can be severely limited in their ability to use such information. The solution seems simple: those who produce and understand the science have a responsibility not only to make their results available, but also to analyze the ecological implications of associated management, planning, and policy issues. Such direct involvement assumes an ethical commitment to biodiversity conservation but carefully avoids biases related to economic considerations, human well-being, or other values. (Recommendations then become powerful tools for planners and policy makers who must consider competing values and tradeoffs to determine the best options.) ACR seeks such science-based participation, but this process requires considerable discipline and selectivity.

In contrast to the traditional reluctance of scientists to weigh in on public policy matters, conservation biologists agree strongly that they should participate directly in land-use planning and conservation policy (Soulé and Orians 2001, Murphy and Noon 2007, Lackey 2007, Chan 2008). However, to maintain a science-based approach, ACR comments on conservation issues only if it can make a significant contribution based on our own scientific work or expertise, or if an issue directly involves the health of our sanctuaries or native species that depend on them. We try to emphasize the limits of certainty in the concepts or evidence used to support our recommendations. We steer clear of values or positions not related to biodiversity conservation—values that might affect trade-offs among management alternatives. So, each decision to act is well considered. Our contributions are focused. There is an art to the effective application of science.

Figure 1. Audubon Canyon Ranch maintains an active role in numerous local and regional conservation issues. For nearly two decades, ACR has actively advocated for the protection of sensitive dunes and dune wetlands at Lawson's Landing, near the north end of Tomales Bay.

Protecting heronries

ACR has valuable knowledge about the ecology of herons and egrets and, therefore, often advises consultants, developers, and planners about buffer distances needed to protect heron or egret nesting colonies from human disturbance. Our recommendations generally reflect the minimum distance at which nesting birds are likely to tolerate human activity near any unspecified site—a distance of 200 m (Figure 2; see *Ardeid* 2003 and Kelly et al. 2006). It is no surprise that planners and developers almost always consider this distance to be too large. In addition, this distance reflects only the effects of a single observer approaching on foot and should be greater to ensure that the birds tolerate groups of people, heavy equipment, or construction activities. To further complicate things, the responses of herons and egrets to disturbance vary dramatically among colony sites, so the uncertainty of this recommendation for any particular site is huge. Consequently, such advice leads to compromises, coupled with strategies for habitat protection, adjustment of project designs, and limits on the timing of proposed activities. ACR's influence in such matters depends on the recognized extent of our expertise and how effectively we explain the possible ecological consequences of each proposal.

ACR has provided key information used to mitigate major threats to heronries at

Napa State Hospital (proposed removal of heronry, Napa County), the Petaluma River (proposed asphalt plant, Sonoma County), Channel Islands Harbor (proposed building location and design, Ventura County), Santa Rosa Creek (repeated hazing and nest tree removal, Sonoma County), DeSilva Island (condominium development, Marin County), Humboldt Bay (restoration and management of a large heronry, Humboldt County), Clear Lake (heronry management, Lake County), Lake Merritt (heronry management, Alameda County), and UC Davis (colony threatens grove of rare oaks, Yolo County). Our role in providing such advice seems to be growing. By making key contributions to the U.S. Fish and Wildlife Service's Comprehensive Conservation Management Plan for the Marin Islands National Wildlife Refuge, ACR helped to ensure the protection of one of the region's most important heronries (see *Ardeid* 2003).

To further strengthen ACR's role in protecting nesting colonies, we collaborated with the San Francisco Bay Bird Observatory to develop an annotated atlas of all known heron and egret nesting colonies in the San Francisco Bay area (www.egret.org/atlas.html). In addition, we provided all nine county development agencies in the region with GIS data files that facilitate the detection of heronries near any proposed development. To make information on the status and location of Bay Area heronries accessible to anyone, ACR landscape ecologist Emiko Condeso created a downloadable reference using Google Earth (www.egret.org/googleearth2.html). A major benefit of ACR's broad network of volunteer field observers is the presence of knowledgeable individuals throughout the region who are willing to act locally to protect heronries and surrounding wetlands.

Conservation teamwork

Conservation planning currently depends strongly on stakeholder groups within ecologically defined areas such as watersheds. Skip Schwartz, ACR's Executive Director, and Gwen Heistand, Resident Biologist at ACR's Bolinas Lagoon Preserve, are longstanding members of the Bolinas Lagoon Technical Advisory Committee (BLTAC). This group advises the Marin County Open Space District (MCOSD) on appropriate management of Bolinas Lagoon. In recent years, management concerns have focused on the long-term dynamics between sediment deposition and tidal circulation—the lifeblood of the estuary. Gwen is also on the joint working group of the Gulf of the Farallones National Marine Sanctuary Advisory Council and MCOSD, which recently produced a key report on Recommendations for Restoration and Management of Bolinas Lagoon. ACR will continue to have an active interest in the health and management of Bolinas Lagoon.

ACR is also a member of the Tomales Bay Watershed Council, a stakeholder group of approximately 30 agencies and organizations who work collaboratively to protect and restore the waters and lands in the Tomales Bay watershed. As a founding member and scientific advisor to the Council, I helped to complete the Tomales Bay Watershed Stewardship Plan in 2003 (www.tomalesbaywatershed.org). Current activities of the Council focus on implementing key objectives of the plan. I am currently working with other biologists on a list of Species of Local Interest, to identify species with special conservation needs in the Tomales Bay watershed.

In a related effort, I helped to develop the Tomales Bay Biodiversity Partnership (www.tomalesbaylife.org), a collaboration of community members and scientists dedicated to developing information that will improve science-based management of Tomales Bay. A primary objective of this project is to conduct a biodiversity inventory, to which ACR Research Associate Rich Stallcup and I contributed a report compiling all documented bird species occurrences in Tomales Bay (Kelly and Stallcup 2003).

Dan Gluesenkamp, ACR's Habitat Protection and Restoration Director, and Andrea Williams, of the National Park Service, recently initiated the nine-county Bay Area Early Detection Network (BAEDN), a partnership of land managers and invasive-species experts organized to coordinate early detection of priority invasive plants—before serious damage occurs. Dan has also been instrumental in leading the Sonoma Marin Weed Management Area, a collaborative group of land managers and citizens that coordinate local expertise and efforts to control invasive weeds (www.marinsonomaweedmanagement.org). Dan's leadership helped in the formation of yet another coalition of land managers and restoration ecologists, the Sonoma-Marin Coastal Grasslands Working Group, which includes grassland restoration expert and Bouverie Preserve Resident Biologist Jeanne Wirka.

Last year, ACR biologists working to restore vernal pools at the Bouverie Preserve organized a workshop for ecologists and con-

Table 1. Examples of planning and policy documents using results from scientific publications and reports by Audubon Canyon Ranch (ACR).

- The Bolinas Lagoon Management Plan
- Tomales Bay Use Management Plan (National Park Service)
- The Tomales Bay Watershed Stewardship Plan
- The Tomales Bay State Park General Plan
- Oil spill impact assessments and associated restoration plans
- California State Office of Spill Prevention and Response planning documents
- California Coastal Commission Report on the effects of mariculture in Drakes Estero
- The San Francisco Bay Area Water Trail Environmental Impact Report (California Coastal Conservancy)
- Designation of Globally Important Bird Areas (American Bird Conservancy)
- Key documents designating Tomales Bay as a Ramsar Wetland of International Importance
- Development of Marine Protected Areas (Marine Life Protection Act)
- Land development permits, Sonoma County
- Lawson's Landing Environmental Impact Report and Master Plan
- Department of Public Works assessment of watershed resources in east Marin County
- U.S. Shorebird Conservation Plan, Southern Pacific Coast Region

◗ Examples beyond central coastal California

- Western Hemisphere Shorebird Reserve Network Conservation Plans for Western Sandpiper and Dunlin
- The Status of Great Blue Heron in British Columbia, B.C. Ministry of Environment, Lands, and Parks
- California Coastal Waterbird Conservation Plan
- Channel Islands Harbor Public Works Plan and associated report by the California Coastal Commission
- Position papers on northern California's Headwaters Forest Reserve Management Plan
- Kansas Gap Analysis Project (to identify species and habitats in need of protection)
- Washington Department of Fish and Wildlife Management Recommendations for Priority Species
- Ontario Ministry of Natural Resources Review of Management Guidelines for Great Blue Herons
- Detailed report to the California Coastal Commission on mariculture in Humboldt Bay
- California Bird Species of Special Concern, California Department of Fish and Game
- California Wildlife Habitat Relationships System, California Interagency Wildlife Task Group

servationists interested in vernal wetlands. The spectacular success of the workshop led to continuing communication that defined a regional group of people who are finding ways to protect and restore vernal pools in Sonoma County. Although the collaborative groups discussed above focus primarily on natural resource management rather than political action per se, their success depends on the broad participation and support of stakeholders—and this requires is a considerable commitment to conservation advocacy.

Cascading information

Although the results of ACR studies are often cited by other investigators, in technical articles, books, and reports, it is difficult to know the extent to which scientific results are actually applied in government reports, environmental impact statements, planning documents, and advocacy letters, to help resolve envirvonmental issues. However, some applications are evident (Table 1). In 1997, I wrote a review of published evidence regarding the impacts of personal watercraft (jet skis) on birds and other wildlife. The paper flew rapidly through electronic communications and the Internet, influencing conservation policy in several areas of the United States and in other countries.

The effects of other work take more time. We recently published recommendations for the protection of extensive feeding areas for herons and egrets (Kelly et al. 2008; see article in this *Ardeid*). This was just a small step toward effective restoration across large wetland areas, but subsequent requests for our results from research centers in Italy and France, dedicated to the conservation of birds and Mediterranean wetlands, suggest a building interest in restoring whole landscapes.

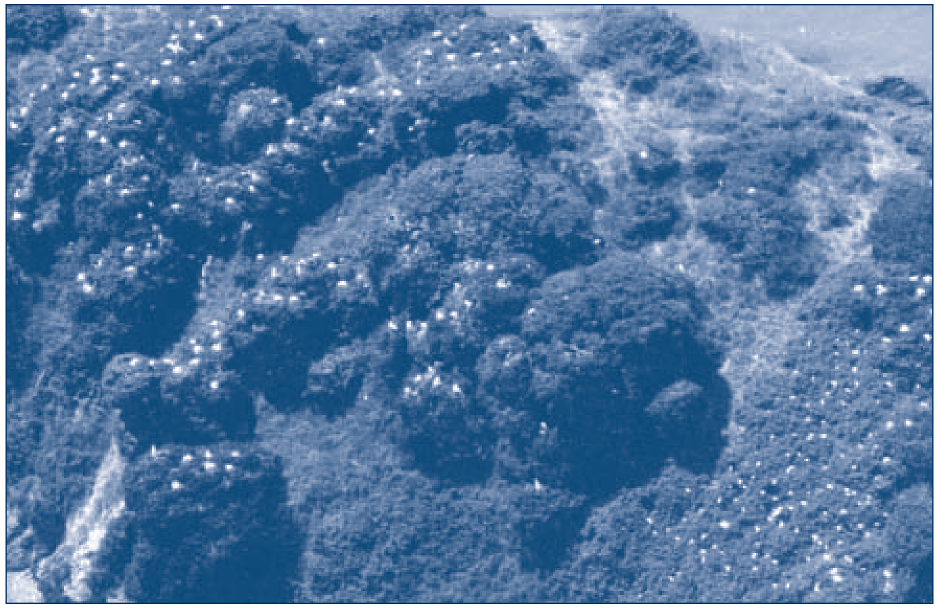

Figure 2. ACR provided key information for the Comprehensive Conservation Management for Plan for Marin Islands National Wildlife Refuge, near San Rafael, where hundreds of herons and egrets nest each year, as seen in this aerial photograph (www.fws.gov/cno/refuges/marin).

Locally, scientific contributions by ACR provided key documentation for recognizing Tomales Bay as a wetland of international importance by the Ramsar Convention, an intergovernmental treaty for the conservation of wetlands (see *Ardeid* 2006). Although difficult to track, the applied results of ACR's scientific work flow as a tributary into the global river of conservation action.

Spin-offs and opportunities

The results of basic ecological studies often generate opportunities for conservation. In the 1990s, ACR conducted an investigation on the ecology of a rare salt marsh plant, Point Reyes bird's beak (*Cordylanthus maritimus* ssp. *palustris;* Kelly and Fletcher 1994). The results have been used in several reports to document habitat values in Tomales Bay and led to requests for information on salt marsh monitoring and management from agencies and investigators working in other California estuaries.

Several natural resource agency management plans and reports have used the published results of ACR investigations of Common Ravens, conducted with colleagues at PRBO Conservation Science (see *Ardeid* 2000–2002, 2004). This work provided opportunities for consulting with land managers and ranchers, including the National Park Service which is concerned with raven predation on nesting waterbirds and federally endangered Snowy Plovers.

Recently, we used the results of studies on bird use, vegetation, and wetland conditions in ACR's Olema Marsh to fuel major collaborative work with the Point Reyes National Seashore on their Giacomini Wetlands Restoration Plan (www.nps.gov/pore/parkmgmt/planning_giacomini_wrp.htm; see *Ardeid* 2005). This effort targets the restoration of natural hydrologic connectivity across the complex wetland landscape of the southern end of Tomales Bay.

Dan Gluesenkamp's current work on the environmental effects of foraging by non-native Wild Turkeys (*Ardeid* 2003) has led to participation in other related work, including the California Department of Fish

Table 2. Examples of local conservation issues resulting in recommendations or comments by ACR.

Public acquisition and protection of properties near ACR lands	Control of feral pigs
Mariculture (oyster farming) in Tomales Bay and Drakes Estero	Government support of Weed Management Areas
Stream bank erosion	Trimming of roadside riparian vegetation in Marin County
Illegal mountain bike trails	Protection of National Park wilderness
Disturbance of waterbirds by kayaks and small boats	Impacts of mosquito abatement
Disturbance of harbor seals	Ranching practices affecting Common Ravens
Disturbance of heron and egret colonies	Management of highway culverts
Management of non-native deer	Wildlife disturbance by personal watercraft
Management of Common Ravens	Restoration of native grasses
Control of wild turkeys	Removal of non-native eucalyptus
Scientific management of Bolinas lagoon	Habitat protection at Tomales Dunes
Protection from development of private lands surrounding the Point Reyes National Seashore (failed Farmland Protection Bill)	Managed water releases into Lagunitas Creek and the Tomales Bay estuary
	Marine Protected Areas (Marine Life Protection Act)
	Grazing on the floodplains of tributaries to Tomales Bay

and Game's (DFG) experimental removal and relocation of turkeys from natural areas. ACR provided detailed reviews of DFG's 2002 plan for introducing turkeys throughout the state, which was ultimately abandoned, and the draft Strategic Plan for Wild Turkey Management in California. The final plan included significant revisions regarding the need to manage impacts to natural areas. The results of Dan's turkey research, currently in preparation, will provide additional opportunities to advise decision makers concerned with the protection of California's wildlands.

ACR's ongoing research on shorebirds in Tomales Bay led to my participation in developing the U.S. Shorebird Conservation Plan (www.fws.gov/shorebirdplan). Similarly, our work on waterbirds led to current teamwork with other scientists and natural resource managers to develop the Coastal California Waterbird Conservation Plan (www.waterbirdconservation.org). These plans identify pressing conservation concerns and provide advice that is ultimately incorporated into numerous local and regional planning documents.

ACR on record

ACR provides comments and recommendations on numerous management issues likely to affect the ecological health of lands surrounding our sanctuaries (Table 2). Some issues require a long-term involvement with the planning process. For example, since the early 1990s, ACR has advocated for the protection of sensitive dunes and dune wetlands at Lawson's Landing, at the northern end of Tomales Bay (Figure 1). Valuable habitats in this area have been degraded by intensive, unregulated recreation and camping for many decades. As Marin County planners and the California Coastal Commission work to develop an EIR, a master plan, and coastal development permits, ACR has repeatedly applied its scientific expertise to highlight the conservation implications of proposed plans. As this process continues, we are encouraged by substantial improvements in the proposed plans that will ensure better protection of this ecological treasure.

An ongoing commitment to conservation advocacy is critical in responding to the enormous challenge of controlling invasive plants, and appropriate action requires a solid, conservation-science perspective. Recently, Dan Gluesenkamp testified before the Marin Municipal Water District on the use of integrated pest management to avoid major ecological damage by invasive weeds. As president of the California Invasive Plant Council, Dan has worked on many fronts to advocate for the control of invasive plants, including travel to Washington, D.C., to discuss invasive plant issues with legislators.

ACR's involvement with conservation planning and advocacy has grown directly out of the stewardship of our sanctuaries. This involvement has been empowered by an increasing awareness of ecological connections with surrounding lands. Now, the conservation crisis demands deeper commitments. ACR's scientific investigations are working harder to examine conservation options, link to planning decisions, and act on what we have learned. Completing this process is the ultimate goal of conservation science: to make sure the results of our work are applied by managers and decision makers responsible for protecting the natural elements and processes of our world.

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Effects of invasive species on nitrogen retention and other issues in the ecology and restoration of coastal prairie. Jeff Corbin, Union College.

Carbon addition and mowing as restoration measures in a coastal California Grassland. Brody Sandel, UC Berkeley.

Ecological indicators in West Coast estuaries. Steven Morgan, Susan Anderson, and others, Pacific Estuarine Ecosystem Indicator Research (PEEIR) Consortium [www-bml.ucdavis.edu/peeir].

Long-term monitoring of the Giacomini wetland. Lorraine Parsons, Point Reyes National Seashore.

Analysis of sedimentation in natural and restored marshes. Lorraine Parsons, Point Reyes National Seashore.

Effects of hemiparasites on environmental heterogeneity and species coexistence in salt marshes. Brenda J. Grewell, UC Davis.

Factors causing summer mortality in Pacific oysters. Fred Griffin, UC Davis Bodega Marine Lab.

A comparison of carbon cycling and material exchange in grasslands dominated by native and exotic grasses in northern California. Laurie Koteen, UC Berkeley.

Black Brant counts at Drakes Estero, Tomales Bay and Bodega Bay. Rod Hug, Santa Rosa, CA.

Strophariaceae of California. Peter Werner, Dennis Desjardin, San Francisco State University.

Effects of landscape context and recreational use on carnivores in northern California. Sara Reed, UC Berkeley.

Impact of an introduced plant pathogen on Lyme disease ecology. Cheryl Briggs and Andrew Swei, UC Berkeley.

Impacts of Wild Turkey (Maleagris galpavo) *on native avifauna in northern California.* Angela Gillingham, Duke University/California State Parks.

Effects of planktivorous fish predation on larvae release patterns of estuarine crabs. Leif Rasmuson, University of Puget Sound.

Investigtion of fossil Olivella (a marine snail) from the Millerton Formation at Toms Point, Tomales Bay. Daniel Muhs, U.S. Geological Survey.

A camera trap survey of mammals and birds at Audubon Canyon Ranch, Rich Tenaza, University of the Pacific, and Chris Wemmer, California Academy of Sciences.

The Watch: project updates

Picher Canyon Heron and Egret Project ◗The fates of all nesting attempts at ACR's Picher Canyon heronry have been monitored annually since 1967 to track long-term variation in nesting behavior and reproduction.

Tomales Bay Shorebird Project ◗Since 1989, we have conducted annual shorebird censuses on Tomales Bay. Each census involves six baywide winter counts and one baywide count each in August and April migration periods. A team of 15–20 volunteer field observers is needed to conduct each count. The data are used to investigate winter population patterns of shorebirds, local habitat values, and conservation implications.

Tomales Bay Waterbird Survey ◗Since 1989–90, teams of 12–15 observers have conducted winter waterbird censuses from survey boats on Tomales Bay. The results provide information on habitat values and conservation needs of more than 50 species, totaling up to 25,000 birds. We are currently investigating relationships between the availability of Pacific herring roe as food for wintering waterbirds and waterbird energy requirements and abundance in Tomales Bay. Future work will focus on trends and determinants of waterbird variation in Tomales Bay.

North Bay Counties Heron and Egret Project ◗Annual monitoring of reproductive activities at all known heron and egret nesting colonies in five northern Bay Area counties began in 1990. We are currently investigating the effects of landscape habitat patterns on nesting herons and egrets. ACR's 250-page *Annotated Atlas and Implications for the Conservation of Heron and Egret Nesting Colonies in the San Francisco Bay Area* includes a detailed analysis of the regional status and trends of herons and egrets, evaluates conservation concerns, and provides individual accounts of all known heronries in the area (available online: www.egret.org/atlas.html). We have also developed a reference that uses Google Earth to show the locations and status of northern Bay Area heronries (www.egret.org/googleearth2.html).

Impacts of Wild Turkeys on Forest Ecosystems ◗Invasive, non-native Wild Turkeys are common at Bouverie Preserve and throughout most of Sonoma County. The goal of this study is to experimentally measure the effects of ground foraging by Wild Turkeys on vegetation and invertebrates in the forest ecosystem of Bouverie Preserve. The results will provide information that can be used by agencies to improve management and control of turkey populations.

Monitoring and Control of Non-Native Crayfish ◗Jeanne Wirka and others are studying the distribution of non-native signal crayfish *(Pacifastucus lenisculus)* in Stuart Creek at Bouverie Preserve and investigating the use of barriers and traps to control the potential impacts of crayfish on native amphibians and other species.

Highway-Generated Nitrogen Deposition in Vernal Wetlands ◗Dan Gluesenkamp, Stuart Weiss, and Jeanne Wirka are quantifying the potential effects of highway-generated nitrogen deposition on Sonoma Valley vernal pools. Enhanced availability of nitrogen near highways might facilitate invasion by non-native plant species and the loss of biodiversity in sensitive vernal wetlands.

Cypress Point Restoration ◗We are conducting a feasibility study for restoring the shoreline dunes at ACR's Cypress Grove Research Center on Tomales Bay. The project includes options for reducing the vulnerability of the Research Center to rising sea levels.

Plant Species Inventory ◗Resident biologists maintain inventories of plant species known to occur on ACR's Tomales Bay properties and at Bouverie and Bolinas Lagoon preserves.

Four Canyons Project ◗ACR's Bolinas Lagoon Preserve contains four canyons that drain the western slope of Bolinas Ridge. We are enhancing the natural complexity of native vegetation in the lower reaches of these canyons, repairing disturbed sites, and eradicating or controlling invasive plant species. This effort will also increase the resistance of these habitat areas to invasive pest plants. Native plant propagation facilities in Volunteer Canyon are being used to grow locally collected plant materials for restoration.

Annual Surveys and Removal of Non-Native *Spartina* and Hybrids ◗In collaboration with the San Francisco Estuary Invasive Spartina Project, Emiko Condeso and Gwen Heistand coordinate and conduct comprehensive field surveys for invasive, non-native *Spartina* in the shoreline marshes of Tomales Bay and Bolinas Lagoon.

Saltmarsh Ice Plant Removal ◗We have eradicated non-native ice plant from marshes and upland edges at Toms Point on Tomales Bay, and native vegetation has recruited into areas where ice plant was once dominant.

Eradication of *Elytrigia pontica* ssp. *pontica* ◗*Elytrigia* is an invasive, non-native perennial grass that forms dense populations in seasonal wetland sites. At Bouverie Preserve, we are eliminating a patch of *Elytrigia* using manual removal and light starvation/solarization (black plastic tarps), and herbicide spot treatments to remove invasive outlier patches.

Nest Boxes ◗Tony Gilbert maintains Western Bluebird nest boxes in the Cypress Grove grasslands. Rich Stallcup maintains several Wood Duck nest boxes along Bear Valley Creek in ACR's Olema Marsh.

Restoration of Coastal Dunes by Removal of *Ammophila arenaria* ◗*Ammophila arenaria* is a highly invasive, non-native plant that alters the topography and function of coastal dunes. This project at ACR's Toms Point, on Tomales Bay, is helping to protect native species that depend on mobile dune ecosystems.

Monitoring and Eradication of Perennial Pepperweed in Tomales Bay ◗Invasive, non-native pepperweed *(Lepidium latifolium)* is known to quickly cover floodplains and estuarine wetlands, compete with native species, and alter habitat values. We are using a variety of methods to remove and monitor the first known infestations in Tomales Bay and, we hope, prevent further invasion. A recent baywide survey of Tomales Bay suggested that the problem is currently limited to a few locations along Walker Creek and a couple of locations at the south end of the bay.

Vernal Pool Restoration and Reintroduction of Imperiled Plants ◗Dan Gluesenkamp, Jeanne Wirka, and Sherry Adams are restoring habitat conditions in the vernal pools at Bouverie Preserve. The project includes the removal of problematic invasive plants and reestablishment of the federally listed Sonoma sunshine *(Blennosperma bakeri)* and California species of conservation concern dwarf downingia *(Downingia pusilla)*. The work involves considerable manual effort by volunteers, propagation and planting of native plants, use of prescribed fire, cattle grazing, and monitoring of changes in vegetation and hydrology. Successful introduction of Sonoma sunshine into the vernal pools of Bouverie Preserve in January 2008 was suggested by the maturation and flowering of this plant the following spring.

THE ARDEID

Conservation Science
and Habitat Protection
at Audubon Canyon Ranch

Ardeid (Ar-DEE-id), N., refers to any member of the family Ardeidae, which includes herons, egrets, and bitterns.

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The inlet channel of Bolinas Lagoon.

Science-based conservation action see page 9

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