Conservation Science
and Stewardship at
Audubon Canyon Ranch

THE ARDEID

2017

Egret telemetry study Fire ecology High-tech trapping for mountain lions
Archaeology and zooarchaeology at Toms Point

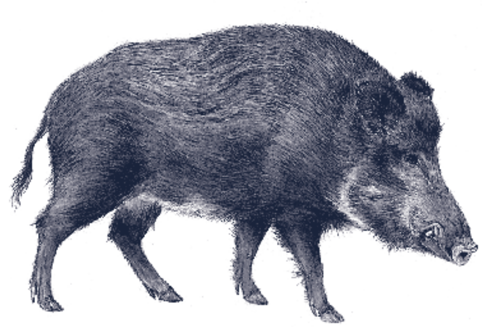
THE ARDEID

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

2017

In this issue

Cover: Great Egret preening. Creative Commons photo.
Ardeid masthead: Great Blue Heron ink wash painting by Claudia Chapline.



Above: *Sus scrofa* (wild pig, or boar) is amply represented in zooarchaeological remains at Toms Point. See page 10.

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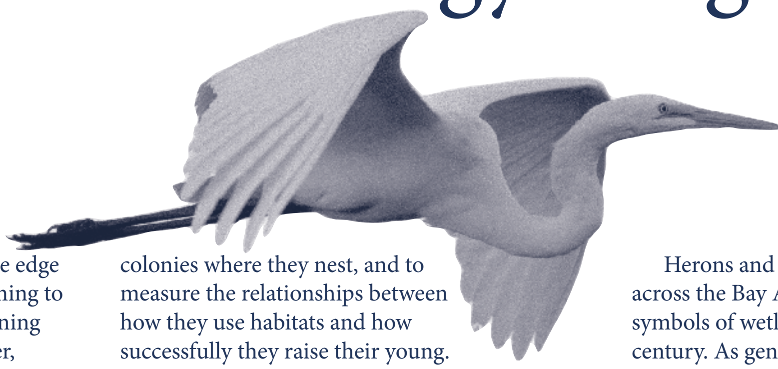
Studying top predators to understand landscape habitat linkages

The Movement Ecology of Egrets

by Scott Jennings



A Great Egret stands tarsus-deep on the edge of a tidal slough, still and silent, seeming to melt in and out of the cold February morning fog. Its long yellow bill stabs into the water, comes up with nothing but drops of water, then strikes again and this time snatches a wriggling stickleback. Having gotten its fill for breakfast (or perhaps not), the egret croaks at something in the sky, then spreads its wings and takes flight, disappearing into the rising mist.

Where did this egret go? Why did it take flight now? Will it come back to this tidal slough tomorrow morning, or will it instead go elsewhere to forage in a flooded pasture? Will this egret's foraging behavior today and tomorrow allow it to raise more young this spring than the rest of the birds in its colony? How do the habitats where this bird forages influence how long it lives? ACR has initiated an exciting new research endeavor, the Heron and Egret Telemetry Project, to answer questions such as these.

We are using tiny, lightweight, solar-powered GPS tags (Figure 1) to record detailed information about Great Egret movement and behavior. These tags will allow us to track individual birds from the wetlands where they forage to the colonies where they nest, and to measure the relationships between how they use habitats and how successfully they raise their young. This is a fundamental pursuit of an emerging field of research termed "movement ecology"—the science of linking the why, where, when, and how of animal movements to the ecological and evolutionary consequences of their behavior (Nathan et al. 2008). A greater understanding of how individual movement and behavior are related to survival and reproductive success will provide a valuable new context to our long-term research on heron and egret nesting abundances across the Bay Area. This expansion of our research will lead to new insights into how these beautiful birds depend on the varied wetland conditions found throughout this urbanized region.

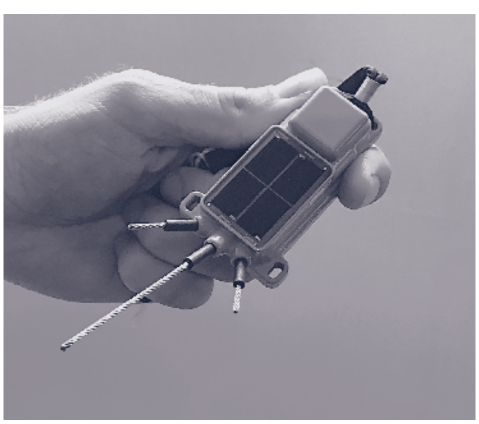


Figure 1. A solar-powered GPS telemetry tag used to generate three-dimensional data on Great Egret movements, postures and behaviors.

Movement ecology of predators guides wetland conservation

Wetlands are the focus of growing attention from scientists and the public for their value as wildlife habitat and for the range of ecosystem services they provide for humans. These services include flood mitigation, removal of pollutants travelling between rivers and oceans, buffering the effects of rising sea levels and increased storm intensity, and aesthetic benefits (Horwitz et al. 2012, Scholte et al. 2016). The San Francisco Estuary is the largest wetland ecosystem in the western United States and provides essential habitat for diverse wildlife, including large proportions of populations of migratory and resident bird species (San Francisco Estuary Partnership 2015). This estuary is a complex, broadly urbanized landscape, with a range of conditions (ecological processes, wildlife values, human land use, recreation, etc.) affected by altered hydrologic patterns and by widespread restoration and conservation efforts (Cohen 2000).

Herons and egrets are ubiquitous in wetlands across the Bay Area and have served as iconic symbols of wetland conservation for over a century. As generalist top predators, they exert top-down influence on the structure of lower trophic levels, altering the abundance and distribution of multiple prey species and, in turn, the effects of their prey on other species (Huang et al. 2015). Food-web connections involving top predators are important elements of healthy ecosystems and may influence rates of carbon cycling (Schmitz et al. 2014). Studying how herons and egrets move across the landscape to select and use habitats is critical to understanding their ecological requirements and, in addition, their role as top predators in sustaining the richness of life in wetland ecosystems.

Research plan

Expanding ACR's heron and egret research to include GPS telemetry will allow us to answer questions about these species' ecological needs that are unanswerable using other methods. The tags we've selected to use in our study collect GPS locations and accelerometry data and send the information wirelessly back to us. Accelerometers collect data on three-dimensional movement that can be used to estimate the energy costs of particular behaviors. Thus, the tags provide data on where birds go and about what they do when they get there.

A key advantage in using GPS telemetry to study animal movement and habitat use is that it avoids the bias that may be associated with field researchers observing individual animals in the field. Rather than choosing when and where to observe animals, a researcher can use GPS tracking to intensively sample behavior and habitat use, and then apply analytical methods to let the animal movements themselves define the spatial and temporal scales of the investigation. Another benefit of using GPS tags is that they generate a tremendous amount of data, measuring animal locations and behavior far more frequently and over much larger landscapes than field observers can. These extensive data will allow us to answer numerous questions in several broad areas. We will begin with descriptive analyses of movement, habitat use, and energetics. This information will provide a foundation for more complex analyses that link individual movements and behaviors to survival and reproductive performance and, ultimately, to population dynamics. Our investigation will be structured around the following five lines of inquiry.

1. Landscape movement and habitat use. We will describe and quantify how individual egrets move across the landscape and the environmental factors that influence their movement and habitat use. This will provide far greater detail about the lives of egrets than previously known.

2. Energy balance. We will investigate and describe individual patterns of energy intake and expenditure across the landscape. We will generate maps of the "energy landscape" of these birds to show how the temporal and spatial costs of movement relate to the benefits of foraging in different areas and habitats.

3. Survival probability. We will quantify the relationships between egret survival and their movement patterns, habitat use, and energy expenditure.

4. Reproductive success. We will quantify the relationships between egret reproductive success (nest survival, number of fledged chicks) and their movement patterns, habitat use, and energy expenditure.

5. Population correlates of individual behavior. We will combine the individual-based aspects of egret behavior and fitness with ACR's long-term studies of regional nesting performance and abundance, to predict how changes in wetland conditions influence the abundance and ecological roles of Great Egrets in the San Francisco Bay area.

ACR's long-term research on heron and egret abundances and reproductive success throughout the Bay Area provides a powerful context for the new telemetry research. This expansion of our work promises new insights into the environmental conditions needed to sustain heron and egret populations. Additionally, this research will set the stage for understanding the role these top predators have in structuring the biological communities where they forage. We will also join collaborative investigations with similar studies in the Midwest and along the East Coast, to reveal how regional populations of herons and egrets differ in their movements, behavior, and environmental requirements.

A nationwide collaboration

This is an ambitious project and we have a tremendous amount to learn, but we are not embarking on this new research alone. ACR is the newest partner in an exciting—now nationwide—science-based education project called "1000 Herons," which integrates the cutting-edge science of GPS telemetry with the unique opportunities for conservation education and outreach this method provides. Key partners in this collaboration are Dr. John Brzorad (Lenoir-Rhyne University, North Carolina), Dr. Alan Maccarone (Friends University, Kansas), Danielle D'Auria (Maine Department of Inland Fisheries and Wildlife), and the U.S. Forest Service's Northern Research Station in the eastern United States.

Drs. Brzorad and Maccarone travelled to California in early June 2017 to teach us the egret capture method they developed and how to safely attach the GPS tags. We use padded foot-hold traps, modified to minimize any risk of injury to the birds, placed in shallow water in egret foraging habitat. We use decoys—lawn flamingoes painted white!—to attract these gregarious foragers from the surrounding area, and a tub stocked with live minnows to guide the birds to the traps. While the traps are set, we hide as close to them as possible (generally 50–100m) so we can release birds as soon as they trigger a trap. Our learning curve during Brzorad and Maccarone's visit was steep, but by the time they left we had attached transmitters to three Great Egrets. These first three egrets were captured at ACR's Toms Point, in northern Tomales Bay. Our goal for the rest of 2017 is to deploy an additional 11 tags, in San Pablo Bay and Suisun Marsh, to study the movement ecology of egrets throughout the area covered by our long-term monitoring of regional nesting colonies.

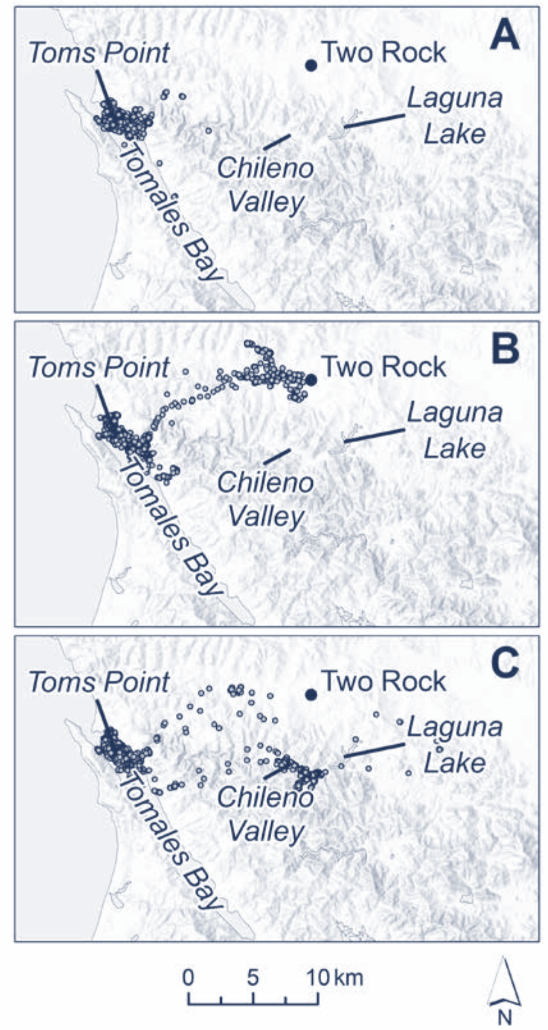


Figure 2. Location data for our first three tagged birds during two weeks in June, 2017. Each dot represents the location of the bird, collected by GPS tag every five minutes.

Initial data reveal interesting patterns

The tagged egrets are already providing a fascinating window into the lives of these birds. For example, although all three birds were captured at Toms Point, and all of them continue return there, they are showing interesting individual differences in where else they go (Figure 2). While the first Great Egret (GREG_1) has remained on Tomales Bay, the other two egrets have spent substantial time inland. GREG_2 has focused its inland time in the Fallon–Two Rock area, in the broad fields and rolling hills of the lowlands

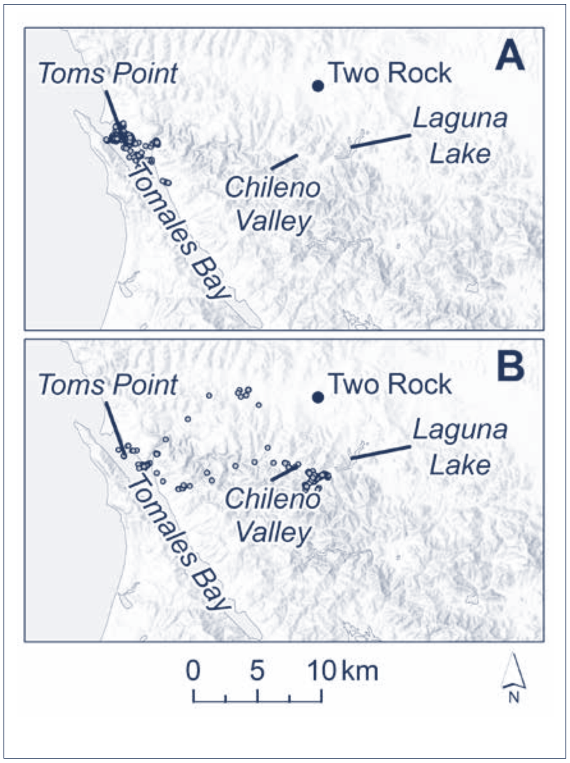


Figure 3. Location data for GREG_3 (A) during a period of several days when eelgrass beds were available for foraging in tidal areas several hours per day versus (B) a period of days when the eelgrass beds were available for less than a few hours per day.

between Petaluma and Bodega Bay. In contrast, GREG_3 has spent most of its inland time in Chileno Valley and, interestingly, has traveled near Laguna Lake but has not visited the lake itself. Both of these birds appear to be focusing their inland foraging at farm ponds and along small creeks, highlighting the habitat values of particular private ranch lands.

Environmental conditions such as tidal patterns also appear to be influencing the movements of our first tagged birds. During low tides, Great Egrets and Great Blue Herons forage in the extensive eelgrass *(Zostera marina)* beds of the intertidal and shallow subtidal areas of Tomales Bay. As the daily tidal cycle shifts from week to week, the amount of time the eelgrass beds are available for foraging during daylight hours fluctuates. These fluctuations in eelgrass availability may be shaping where GREG_3 spends its time. During a week when the eelgrass was available (water level ≤ 1 foot above MLLW) for 3.5–5.4 hours per day, GREG_3 remained on Tomales Bay (Figure 3A). However, during the following week, eelgrass availability dropped to only 0.8–3.4 hours per day, and it was during this time that this bird traveled inland to forage along Chileno Creek and other areas (Figure 3B).

Increasing ACR's commitment to heron and egret conservation

As the Heron and Egret Telemetry Project continues to generate new information on the movement patterns and habitat use of these birds (Figure 4), we will gain important new insights for protecting the lands they rely on—with particular attention to shifting climate and land-use patterns. For example, comparing the time budgets and reproductive performance of birds that stay along the coast (like GREG_1) to those that spend part of their time inland (like GREG_2 and GREG_3) can provide critical information about the relative importance of different habitats.

Additionally, by understanding how current environmental conditions influence egret movement and habitat use, we can predict how climate change or shifting land-use patterns will affect this species. For example, if eelgrass beds begin to drown because they are unable move to higher elevations as sea level rises, then egrets may depend more strongly on inland ponds and creeks. At the same time, shifting precipitation patterns resulting from climate change may alter the hydrology, and thus foraging quality, of these inland foraging areas, possibly affecting the number of egrets that can nest in the region.

Figure 4. A solar-powered GPS telemetry tag transmits information on Great Egret movements and habitat use. Photo by Barbara Wechsberg.

Knowledge about the choices individual egrets make as they move through large wetland landscapes, and how these choices influence egret population dynamics, can help us to guide land managers, agencies, and others working to manage environmental processes and protect the quality of wetlands. This new direction in ACR research will open new opportunities for national and international collaboration and expand ACR's role as a regional leader in conservation science.

Avian Ecologist Scott Jennings is the lead investigator on ACR's Heron and Egret Telemetry Project.

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California fire ecology

The Foundation

by Sasha Berleman

Fire is a keystone ecological process, and most of California's ecosystems have evolved to depend on it as a dynamic process that maintains ecological resiliency. As a very conservative estimate, approximately 4.5 million acres (1.8 million ha) burned annually in California before European arrival; this equates to 88% of the total wildfire area during the "extreme" wildfire decade of 1994–2004 for the entire United States (Stephens et al. 2007). Because of this history of annual burning, smoky skies were typical through most of the summer, and fires were patchy, of mixed severity, and self-limiting in size (Keeley 2002). Studies on lightning strike distributions show that lightning occurrence in the North Coast and Central Coast regions of California is among the lowest in the state (Figures 1 and 2, Cuthrell et al. 2012), yet ecosystems in these regions are among the most significantly fire dependent. California's landscape habitat configurations depend on fire as an ecological process. Particularly in the North and Central Coasts, this fire dependency is primarily a result of anthropogenic influences, as Native American populations were at remarkably high densities here (Keeley 2002).

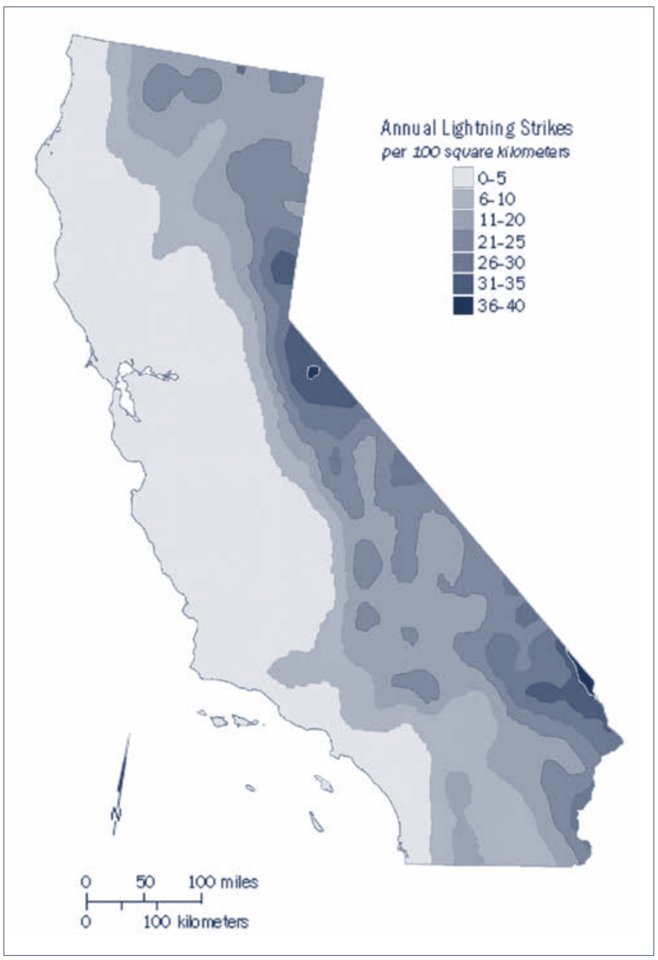

Figure 1. Distribution of lightning strikes (average annual densities per 100 km2) in California, 1985-2000 (from Cuthrell et al. 2012). Lightning occurrence in the North Coast and Central Coast is among the lowest in the state.

For at least 13,000 years, Native American tribes across California used fire for a myriad of reasons (Anderson 2005; Keeley 2002). The benefits of using prescribed fire as a management tool included, but were certainly not limited to: reduction of wildfire risk to villages; management of pests and pathogens, such as acorn weevils and mistletoe, to improve acorn and other food crops while limiting disease; improvement of forage availability and value; habitat improvement for people and wildlife alike; stimulation of native bulbs and grasses; production of high-quality basketry materials; harvesting of insects such as grasshoppers and wasp larvae for food; and corralling of game animals such as rabbits, deer, and elk.

As a result of the intensive and extensive fire-based land management by native people, each of California's ecosystems came to depend on site-specific fire regimes. Fire regimes are defined by the combinations of fire qualities that maintain resilient ecosystems. Factors that make up fire regimes are seasonality, fire-return interval, size, spatial complexity, intensity, severity, and fire type. Extensive research combining dendrochronology, charcoal deposition, and ethnographic interviews have helped to determine and define fire regimes for ecosystems across California. Some of the plant-specific adaptations to fire include but are not limited to: for trees, self-pruning limbs, thick bark, and resprouting; for native grasses, perennial and bunched structures with deep roots; and for native forbs, long-lived bulbs and seeds that require smoke or heat to germinate. Fire regimes maintained by Native American tribes for thousands of years sustained open meadows with high forb abundance and selected for large, old trees with open and diverse understories.

The problem: Impact of regime shift

With the arrival of non-native peoples in California in the 1800s came a rapid depopulation of Native Americans and a Euro-American culture that actively declared the use of fire illegal. So began the era of fire suppression in California, and with the removal of land stewardship by Native American peoples also came rapid change to ecosystem structure and function. Whereas Native American tribes had managed lands for open meadows, big trees, high diversity, and resilience against dramatic sudden change, our meadows and open woodlands became encroached with native and non-native invaders alike—trees and shrubs and grasses that do not benefit from fire but whose populations increase and encroach rapidly in the absence of fire. This change in ecosystem structure—from fewer, larger trees and open space to large trees with an understory of densely populated and unhealthy smaller trees and heavy accumulated fuel loads—led to increased ecosystem stress, as a result of resource competition from overstocked trees, and reduced resiliency of the ecosystem against catastrophic change. As resource competition weakens the health of individual native perennial plants, this increased stress results in higher susceptibility to pathogens and pests, reduced capacity to tolerate drought, and ever-increasing vulnerability to catastrophic fire—all challenges that threaten ecosystem conversion to new ecological states that no longer resemble their predecessors. The widespread encroachment of invasive plants, combined with increased fuel

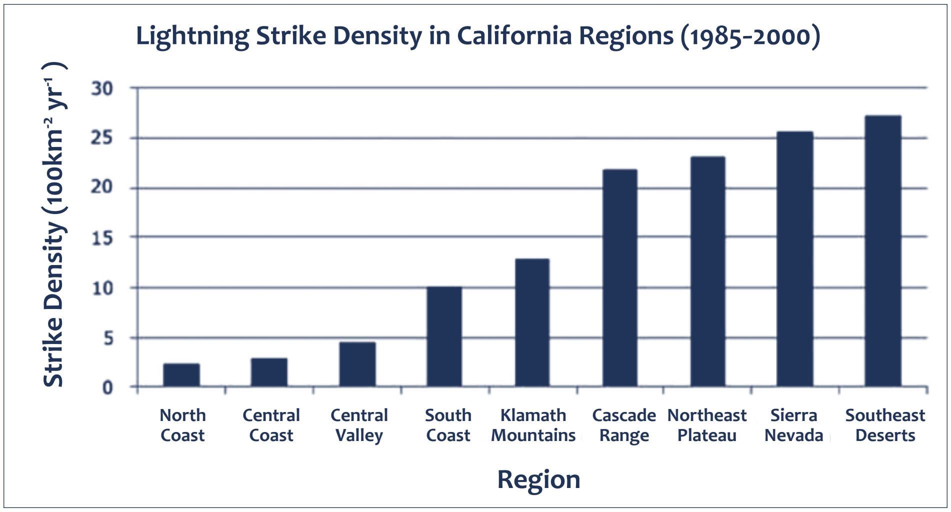

Figure 2. Average annual lightning-strike densities per 100 km^2 in California bioregions, 1985-2000 (from Cuthrell et al. 2012). See Figure 1: The statewide distribution of lightning strikes.

Our First Burns at ACR

On May 30 this year at Bouverie Preserve, ACR accomplished its first major prescribed burn event of its Fire Ecology Program (Figure 3). Prescribed burns were conducted on 17.5 acres (7.1 ha) of grassland and oak savannah. Our ecological objectives within the burn areas were to (1) consume 40 years of thatch from non-native annual grass, (2) tip the scales in favor of native plants for 2-5 years by reducing competition from non-native annual grasses and stimulating fire-adapted seeds, and (3) consume leaf litter and debris under the oaks. In the open grassland, our first objective was well met. Fire was lit in a corner at the highest point of the unit and was carried across the unit in three-meter strips. These strips were allowed to burn into each other until there was no longer any fuel available and the fire went out on its own. An assessment of ecological monitoring plots next year will confirm whether the second objective was met in year one. However, based on initial observations on site, we fully expect that this objective was also met (Figure 4). About four of our 17.5 total acres did not carry fire and have not yet burned. These were areas beneath the oak trees where the shade held moisture in the grass, causing the fire to go out on its own when it reached these locations. This fire-behavior result is in fact ecologically ideal, as we intend to go back into this remaining oak understory in the fall to complete the prescribed burns, the timing of which will allow us to better control native acorn weevil populations and to clear leaf litter and debris just before the acorn crop falls.

Figure 3. To ensure desired fire behavior and effects before continuing with ignitions, Burn Boss Ben Jacobs observes fire behavior during a test burn, with CAL FIRE and ACR representatives looking on.

Additionally, we were successful in meeting our objective to make this a cooperative burn. We had engines and personnel from eight different local agencies on site. All of the diverse teams worked seamlessly together and voiced their enthusiasm for coming back to do this again. For the firefighters, this experience helped them all to practice working as a cohesive unit and to improve their communication skills. Firefighters also had the opportunity to see and receive training on ignition strategies, which is key to increasing the pace and scale of fire use in ecologically mindful ways. In addition to the diverse operational crews, we had diverse observers as well—members from a local tribe, land managers and ecologists from multiple land preservation agencies around the region, and many local media representatives.

Figure 4. Photographs one week before and two days after ACR's first prescribed burns at Bouverie Preserve, as part of its Fire Ecology Program.

loads, dramatically changed fire behavior in our landscapes. We now see high-severity fires that are not self-limiting and burn over much larger areas, rather than less-severe burns that generate a landscape mosaic of fire effects.

Fire ecology is undeniably tied to anthropogenic impacts, and recent studies have even shown that fire frequencies, sizes, and severities are not only tied to but are undeniably driven by anthropogenic factors, with climate being only a secondary contributing factor to these anthropogenic-fire eras (Skinner et al. 2016). Humans living in native North American tribes operated as a keystone species for thousands of years in California's ecosystems (Kat Anderson, U.C. Davis, personal communication), and their removal from the landscapes with European arrival, combined with fire suppression and the "wilderness" ideology that nature and humans should be kept separate, has created some of the greatest land management challenges of modern times. While people are capable of bringing a myriad of effects to landscapes, we need to make conscious decisions about those effects we have. While wilderness ideology has protected many landscapes from threats of development and conversion, we must collectively acknowledge that we put these same lands we aim to protect at risk through refusal to manage them, and that, in fact, the decision to not manage lands is a management decision that puts all of our beloved landscapes at risk.

The solution

As a culture, we are finally beginning to understand our role in managing our landscapes. We finally see that in California, the question is not if but, rather, when the next fire will occur. Wildland fires cannot be prevented, but merely postponed, and often have dramatic consequences for ecosystems and people alike. California is in a severe fire deficit, and it will require an "all-hands, all-lands approach" to make a positive impact on future landscape conditions. Across the state, all agencies have agreed that we need more fire on the ground, specifically in the forms of prescribed fire (planned ignitions with specific objectives) and managed wildfire (allowing wildfires to burn under supervision where and when they pose no direct threat to life or property). Not only are land management agencies in agreement on these objectives, but research on air quality impacts has also brought support from the California Air Resources Board. We now have cost-benefit analyses showing that the negative impacts of smoke from mega-fires such as the Rim Fire far outweigh the impacts of smoke that would be produced from increased use of prescribed fire across the state (Long et al. 2017).

We have the honor of living in this exciting time, when science, social, and political cultures are all finding alignment. We now have an opportunity to reengage in active ecosystem management, but in a knowledgeable and beneficial way, for the good of people, and for the good of the environments we so cherish and depend on to thrive.

Dr. Sasha Berleman leads ACR's new Fire Ecology Program. She has a Ph.D. from U.C. Berkeley in Wildland Fire Science, with a focus on prescribed fire, and is a qualified firefighter with extensive hands-on prescribed fire experience.

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Investigating Native American history at Tomales Bay

Toms Point Archaeology

by Tsim D. Schneider and Lee M. Panich

In 2015 and 2016 we conducted an archaeological research project at Audubon Canyon Ranch's Toms Point preserve (Figure 1). The field research was part of a larger project aimed at studying indigenous Coast Miwok living during and especially after the Mission Period (1769–1830s). Many readers will be familiar with the 21 Spanish missions that stretch from Sonoma to San Diego, California. The locations of missions within the province of Alta California (the name given to colonial territory north of San Diego) were determined by Franciscan missionaries who sought to convert Native Californians to Christianity and, in doing so, to inexpensively populate the remote northern frontier of New Spain with loyal subjects. Accompanying the missions, presidios (forts) and pueblos (towns) rounded out the blueprint designed to block competing Russian interests in colonizing California. Many present-day Californians—especially fourth-graders who build, or now purchase, small models of missions—learn how the Franciscan priests stationed at each mission enticed California Indians to join the Church and convinced them to abandon their homes, their languages, and cultures. But was this always the case?

Our continuing archaeological and historical research examines the interactions between native communities and colonial missions, as well as the numerous instances of native resistance and resiliency during and following California's Mission Period (Panich and Schneider 2014, 2015). As we see it, this work counters popular views of missions as places of confinement and cultural loss for California tribes. Doing so requires carefully balancing well established accounts of native mortality, cultural transformation, and violence at the missions with significant examples of indigenous and mission-sponsored resistance. The term "resistance" might bring to mind images of violent attacks on missions and missionaries. Such assaults certainly did take place, although native people also found other ways to remain connected to their homes and loved ones. Padre-approved furloughs, creative living arrangements, and illicit departures from missions helped to circumvent restrictions on food collecting, dances, and traditional rites of passage imposed at many missions. For us, the continuation of such activities beyond the walls of Spanish missions offers a compelling, alternative understanding of the Native American experience in colonial California.

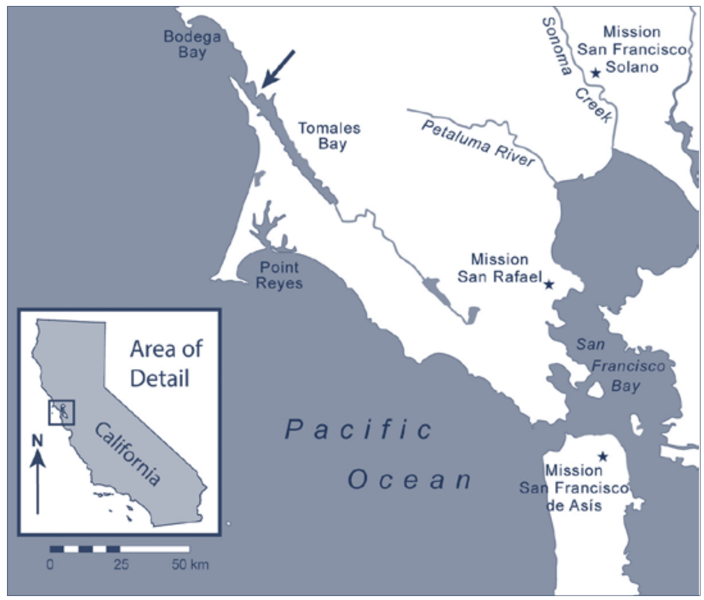

Figure 1. Archaeological research took place in 2015 and 2016 at ACR's Toms Point (indicated by the arrow) in northern Tomales Bay.

Colonial Tomales Bay

Few archaeologists are investigating this different point of view. Compared to the highly visible remains of mission chapels and walls seen on the present-day landscape, evidence for the continuation of indigenous hunting and gathering, dances, and mortuary practices can be more challenging to detect in the archaeological record. But it's not impossible. What makes Tomales Bay especially intriguing is its role as a homeland since time immemorial, a refuge area for native people fleeing colonial projects, and an important site of redirection for Coast Miwok after the missions were secularized in the 1830s. Previous archaeology, further discussed below, recorded numerous sites along Tomales Bay, including several sites that date to the Late Period (AD 1000 to 1800) and still older places. During the Mission Period, padres recorded the names and home villages of native people baptized at each mission. At Mission San Rafael, for example, padres listed several Tomales Bay communities—including Segloque, Calupetamal, Xotomcohui, Echacolom, Yuipa, and others—suggesting a complex social landscape at the time of European contact. Recorded 40 years after the first Coast Miwok were baptized at Mission San Francisco in 1783 (Milliken 1995), the Tomales Bay people reported at Mission San Rafael also reflect an improbable story of resiliency for native cultures and identities.

Missionization was neither swift nor complete, and remote western Marin County appears to have facilitated critical continuities between Coast Miwok people and place, even as other colonial programs came and went from the landscape. The operation of Fort Ross from 1812 to 1841 briefly repositioned Tomales Bay communities in an international borderland sandwiched by the Russian mercantile colony to the north and Spanish missions to the south and east. During and following the secularization of missions, wealthy citizens of Mexico and ex-military personnel acquired vast tracts of land throughout Marin and Sonoma counties—former mission property held in trust for California Indians—and established ranches that that thrived on native labor.

During the 1840s to 1860s, when the United States took possession of California, Tomales Bay transformed once more. At Toms Point, George Thomas Wood, or "Tom Vaquero," established and operated a trading post. Wood had jumped ship sometime in the 1840s and made a living selling cow hides and tallow to an assortment of international ships that cruised along the Pacific Coast. The trading post was made profitable by an indigenous work force, most likely Coast Miwok people who originally hailed from Tomales Bay. In 1916, one year before his death at the age of 95, Charles Lauff narrated his memories of early Marin County for the *San Rafael Independent,* including his visit to the trading post:

> Tom's home was the rendezvous of all of the Indian tribes… During the summers of 1845–46, it was not an uncommon sight to see 1,000 Indians along the bay shore. They would come overland with their supplies of hides, tallow and skins, and would wait for weeks for the arrival of a vessel… Among them were carpenters, cobblers, cooks and blacksmiths. Some of the younger Indians had fairly good voices and would sing the Latin hymns taught them by the padres while altar boys.

This quote suggests that the trading post may have been an important hub—and homeland—for Coast Miwok people returning home from other colonial places. By combining such information with field investigations at Toms Point, we seek to understand just how Coast Miwok people made decisions about keeping their past and selectively incorporating new social and economic practices.

Toms Point archaeology, 2015–2016

Of special relevance to our project, an 1856 United States Coast Survey (USCS) report describes the placement of a permanent survey marker on Toms Point, "immediately above and to the southward of Tom Vaquero's house." An 1862 USCS map confirms the location of the Toms Point datum and shows an L-shaped structure surrounded by three small triangles that we interpret to be the trading post and the houses of native laborers. The report and map were important starting points for designing our archaeological research methodology at Toms Point.

With permission from Audubon Canyon Ranch and the Federated Indians of Graton Rancheria, the sovereign tribe of Coast Miwok and Southern Pomo people whose ancestral lands include all of present-day Marin County and southern Sonoma County, we commenced archaeological field investigations during the late spring of 2015.

Our initial trips to Tomales Bay were oriented around locating previously recorded archaeological sites that might contain mission or post-mission era artifacts. Beginning in the early 1900s, for instance, archaeologists from UC Berkeley surveyed and recorded numerous "prehistoric" archaeological sites along the shores of San Francisco, Tomales, and Bodega bays. A little later, archaeologists searching primarily for evidence of Francis Drake's 1579 stopover in California returned to Point Reyes and Tomales Bay to systemically excavate several previously identified shellmounds. At around the same time, many Point Reyes and Tomales Bay sites—such as the "McClure" site across the bay from the Toms Point preserve—were extensively studied to collect time-sensitive artifacts for the purpose of building a local prehistoric chronology. A third pulse of research occurred in the 1960s, when an amateur archaeologist amassed a large collection of precolonial and historic artifacts from the beaches of Tomales Bay. However, none of the previous archaeological studies discuss Wood or the shoreline trading post.

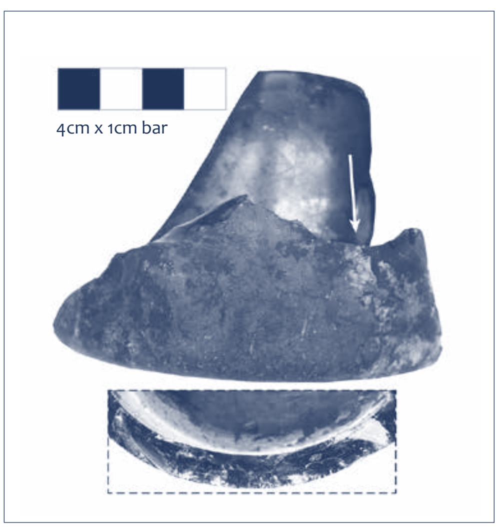

Figure 2. The arrow points to a section on a glass bottle base exhibiting purposeful flaking (see inset), which suggests creative reuse of discarded materials using traditional stone tool manufacturing techniques.

The 2015 archaeological field investigations took place at archaeological site CA-MRN-202, the most likely location of the trading post. In addition to mapping the site and collecting a few scattered surface artifacts, we used ground penetrating radar (GPR) to help pinpoint buried archaeological remains and features that could be identified later in a few well placed test excavation units. The GPR survey identified several small anomalies just below the ground surface, and our excavations at CA-MRN-202 revealed numerous metal artifacts that may have been salvaged from the wreck of the *Oxford,* which ran aground off Sand Point in 1852. The panel of an iron box stove, broken glass and pottery, chipped stone and bottle glass (Figure 2), pig bones, fish and shellfish remains, and five AMS (Accelerator Mass Spectrometry) radiocarbon dates suggested that we had located a midden, or trash dump, associated with the historic trading post. Architectural remains, however, are more elusive.

With funding from a National Science Foundation grant, we returned to Toms Point for three weeks during the summer of 2016. Our research team included students from Santa Clara University and UC Santa Cruz (Figure 3). The bulk of this field season was concentrated at CA-MRN-202, where we sought to augment previously excavated collections from the site and confirm site chronology in a dynamic dune system. We excavated six additional meter-square units and several smaller (10-cm diameter) auger units to determine whether an older component of the site lay deeply buried below the historic midden. To do so, we carefully exposed a small, half-meter-wide cut in the dune face nearly three meters below the trading post midden and collected archaeological samples for dating purposes. Two AMS radiocarbon determinations suggest that this older deposit is approximately 1,000 years old, a testament to the long history of native residence in the area.

In 2016 we also examined two additional archaeological sites at Toms Point, CA-MRN-201 and CA-MRN-363, to add important detail about indigenous landscape use during precontact and colonial times. Similar to the methods employed at CA-MRN-202, we mapped each

Figure 3. Students from UC Santa Cruz and Santa Clara University conducted field investigations at three sites on Toms Point in 2016.

site and then conducted a systematic surface artifact collection to identify the size and composition of each site. Radiocarbon dates from clamshell collected from the surface of CA-MRN-201 suggest that one part of the site dates to the same time period as the historic trading post. To our surprise, another area of CA-MRN-201 produced radiocarbon ages ranging from approximately 4,500 to 2,500 years before present. In addition to mapping and surface collection at CA-MRN-363, we excavated a single test excavation unit to assess site depth and age. The clear absence of mass-produced metal, glass, and pottery artifacts at CA-MRN-363 was confirmed by multiple 4,000-year-old AMS radiocarbon dates associated with a 50-cm-thick shell layer. Taken together, the radiocarbon data further open the Toms Point preserve to new ways of understanding the persistent and dynamic history of native land use as reflected in three areas of the landform.

Looking forward

At the conclusion of each of the 2015 and 2016 field seasons, all of the artifacts and soil samples from Toms Point were transported to our respective laboratories at UC Santa Cruz and Santa Clara University for identification, cataloging, and analysis. The current catalog of Toms Point artifacts consists of historic glass and pottery, metal artifacts and debris, chipped stone and groundstone fragments, shellfish remains, and several thousand pieces of faunal bone. We will be submitting soil samples for archaeological flotation and paleoethnobotanical analyses to recover tiny items from the soil and determine past plant communities and diet among Toms Point residents. In the accompanying article in this issue, Dr. Anneke Janzen and Amanda Hill describe the extensive assemblage of zooarchaeological evidence from the 2015 and 2016 seasons at CA-MRN-202 and CA-MRN-363.

Our interpretations of the archaeology at Toms Point will continue to develop in the next few years as greater portions of the artifact assemblage undergo analysis. At this stage, however, it is already apparent that still more can be done to illuminate the picture of colonial-era indigenous communities in Marin County. Specifically, is Toms Point an exceptional case of native autonomy, or is it representative of a more common pattern found throughout California? How does Toms Point connect to the broader social landscapes of the post-Mission Period in the San Francisco Bay region? To help answer these questions, we'll turn to the geochemical sourcing of obsidian artifacts to identify resilient social and economic exchange systems including—and extending beyond—Toms Point. An isotope study is also underway using archaeological clamshell to determine the seasonal return of native people to Toms Point. In other words, how did indigenous Coast Miwok fit the effects of colonial-era influences into their own schedules and social priorities? We'll also continue to explore the rich collection of historical documents, maps, travelers' journals, censuses, and mission sacramental registers to help us reconstruct the resilient social worlds and native lives in colonial California.

Acknowledgements.

We have been fortunate to conduct our research in one of the most beautiful places in the world. For that, we are especially grateful to Audubon Canyon Ranch and the Federated Indians of Graton Rancheria for supporting and seeing value in our research at Toms Point. We also acknowledge and appreciate the efforts of our students from UC Santa Cruz and Santa Clara University. Research for this project was funded by a Collaborative Research Grant from the National Science Foundation (BCS 1558987 and 1559666) and by an American Philosophical Society Franklin Research Grant.

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Archaeological faunas shed light on the diets of past Toms Point residents

Toms Point Zooarchaeology

by Anneke Janzen, Amanda Hill, and Tsim D. Schneider

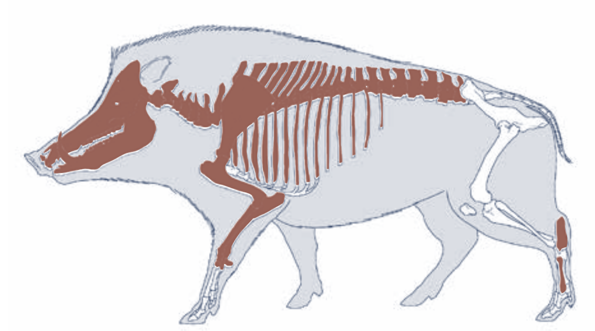

Figure 1. Pig skeletal elements recovered at Toms Point are indicated by shaded areas. In the case of axial elements (vertebrae, ribs), whole sections are highlighted, even though not all vertebrae from the skeleton were recovered. Figure modified from Coutureau (2003).

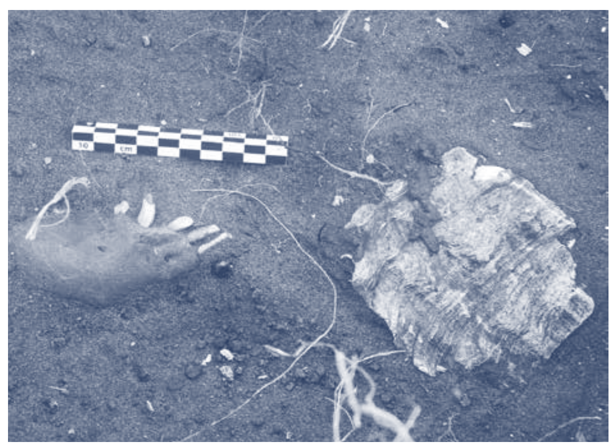

Figure 2. This pig mandible (left) and abalone shell fragment (right) were found in association.

Faunal remains from archaeological sites can provide a wealth of information about past environments, subsistence strategies, and social relations. When identifiable in the archaeological record, the species exploited by past human groups have the power to illuminate the range of environments accessed by people. Furthermore, if the resources are highly seasonal, then the specialized techniques of zooarchaeological analysis can bring to light people's scheduling decisions concerning their use.

Foodways—or foraging strategies and culinary practices—of Native Californians in prehistory have been studied extensively. However, while missions and ranchos have seen numerous studies of faunal remains, the foodways of Native Californians living outside of colonial settings and in the wake of the Mission Period (1769–1830s) are relatively understudied. Our research at ACR's Toms Point preserve (see page 7, Figure 1) and this zooarchaeological study, which examines the faunal assemblage from two Toms Point archaeological sites, evaluate the various ways native people kept tradition and took on new ways of living in the years following missionization. The analysis of faunal remains from Toms Point offers a unique opportunity to learn more about resource use and culinary practices during this time period. Fundamentally, we ask this question: did Native Californians living at Toms Point continue to exploit traditionally utilized animals, or did they incorporate introduced Old World domesticates?

This article reports on the faunal assemblages from recent excavations of two archaeological sites at Toms Point preserve (CA-MRN-202 and CA-MRN-363). The larger of the two assemblages, CA-MRN-202, yielded a diverse array of animal bones, which provides evidence for native foodways in the post-Mission period at Tomales Bay. The use of wild and domestic taxa and marine and terrestrial fauna shows a unique combination of species traditionally exploited by indigenous Coast Miwok peoples and other species brought in by the Spanish.

CA-MRN-202

In the previous article, Tsim Schneider and Lee Panich outlined the 2015 and 2016 archaeological investigations at three sites in the Toms Point preserve. At Toms Point, through the 1840s to 1860s, George Wood enlisted indigenous Coast Miwok to aid in his entrepreneurial endeavors, which involved selling hides, tallow, grain, and abalone to merchant ships. An eyewitness account from Charles Lauff (2009 [1916]) indicates that Coast Miwok laborers who worked and lived at George Wood's trading post also maintained traditional cultural practices.

Fauna recovered from excavations at CA-MRN-202 reveal diverse wild species exploited by the Toms Point occupants, including wild and domestic fauna, waterfowl, marine mammals, and fishes. Table 1 outlines the vertebrate faunal remains (excluding fishes) identifiable to narrow taxonomic groupings. This table excludes very fragmentary specimens identifiable, for example, to just "large mammal."

The fishes recovered from the 2016 excavations at CA-MRN-202 are currently undergoing analysis, and here we present data from the 2015 excavations. The taxa recovered generally point to nearshore fishing activities. Most fish remains were identifiable to family only (Table 2). Most numerous are fishes belonging to the family Embiotocidae (surfperches), Clupeidae (sardines and herrings), and Atherinopsidae (neotropical silversides). These broad taxonomic groups include species that occupy a range of environments, so it is not possible to deduce the environments in which they were captured. Only three elements were identifiable to species. One, the Pacific herring is found in a range of environments, including marine, freshwater, and/or brackish waters, and therefore does not lend any specific information on environments exploited—although, to this day, huge numbers of Pacific herring spawn in the eelgrasss beds of Tomales Bay each winter. In addition, both the pile perch and cabezon inhabit rocky intertidal areas and kelp beds, indicating that these areas were favored for fishing.

Table 1. Identifiable faunal remains from Toms Point (CA-MRN-202). We use the abbreviation "cf." (from the Latin *confer*) to indicate the specimen is very similar to a particular taxonomic group but is not securely identified. We use the abbreviation "sp." when specimens are attributable to a genus but not species.

Taxon	Common Name	Number of specimens
Aechmophorus occidentalis	Western Grebe	2
Anas clypeata	Northern Shoveler	6
Anas cyanoptera	Cinnamon Teal	2
Anas platyrhynchos	Mallard	5
Anas platyrhynchos (cf.)	Mallard (cf.)	2
Anas sp. (small)	small dabbling duck	1
Anas sp. (medium)	medium dabbling duck	28
Aythya valisineria	Canvasback	1
Branta canadensis	Canada Goose	2
Branta canadensis (cf.)	Canada Goose (cf.)	1
Chen hyperborea	Snow Goose	1
Anser albifrons	Greater White-fronted Goose	1
Anatidae (medium)	medium ducks, geese, swans	8
Anatidae (large)	large ducks, geese, swans	1
Anatidae (cf. large)	large ducks, geese, swans	1
Buteo sp.	hawk	1
Podilymbus podiceps	Pied-billed Grebe	1
Melanitta sp.	scoter	2
Phalacrocorax penicillatus	Brandt's Cormorant	4
Phalacrocorax sp.	cormorant	2
Gallus gallus	Chicken	4
Gallus gallus (cf.)	Chicken (cf.)	1
Galliformes	chicken-like bird	1
Gavia pacifica	Pacific Loon	1
Gavia immer	Common Loon	1
Gavidae	loon	1
Larus sp.	gull	1
Larus (cf.)	gull (cf.)	1
Laridae	gull	1
Pelecanus occidentalis	Brown Pelican	1
Phoca vitulina	harbor seal	14
Enhydra lutris	sea otter	4
Lynx rufus	bobcat	1
Puma concolor	mountain lion	1
Bos taurus	cow	18
Bos taurus (cf.)	cow (cf.)	2
Caprinae	sheep/goat	1
Odocoileus hemionus	mule deer	1
Ruminant (medium)	medium ruminant	1
Sus scrofa	pig	65
Artiodactyla (medium; indeterminate)	medium artiodactyl	4
Artiodactyla (large; indeterminate)	large artiodactyl	13
Equus sp.	horse/donkey	1
Sylvilagus bachmani	brush rabbit	3
Lepus californicus	black-tailed jackrabbit	7
Leporidae	rabbit (indeterminate)	40
Ondatra zibethicus	muskrat	1
Thomomys sp.	northern pocket gopher	5
Peromyscus sp.	deer mouse	2
Sciuridae	squirrel	1
Scapanus latimanus	mole	3
Total		273

Table 2. Fish remains from the 2015 excavations at Toms Point (CA-MRN-202); "cf." indicates very similar, but unconfirmed, association with a particular taxonomic group.

Taxon	Common Name	Number of specimens
Chondrichtyes	cartilaginous fish (indeterminate)	1
Actinopterygii	ray-finned fish (indeterminate)	2
Atherinopsidae	neotropical silversides	5
Clupeidae	sardines & herrings	9
Clupea pallasii	Pacific herring	1
Embiotocidae	surfperches	16
Embiotocidae (cf.)	surfperches	2
Rhacochilus vacca	pile perch	1
Scorpaenichthys marmoratus	cabezon	1
Sebastes sp.	rockfish	4
Total		42

Among marine mammals, the remains of both sea otters and harbor seals were recovered. Both species can be found close to land. Harbor seals can frequently be encountered near shore where they haul out, and sea otters commonly inhabited kelp beds (Grigg et al. 2009). Sea otters were nearly extirpated in the nineteenth century as a consequence of the Russian-American Company enterprise at Fort Ross (1812–1841) and, with the exception of extremely rare occurrences, they are currently absent in Tomales Bay. The profits of this Russian mercantile colony hinged primarily on Native Alaskan laborers who were highly skilled at hunting sea mammals from their lightweight skin boats (baidarkas). Yet Native Californians and Americans were also involved to lesser or greater intensities in the maritime fur trade and hunting sea otters in Point Reyes, Tomales Bay, and Bodega Bay waters. It is quite possible that the Toms Point occupants took part in these endeavors.

Terrestrial carnivores are rare at the site; mountain lion and bobcat are each represented by only one phalanx (finger bone). The absence of other parts of the skeleton from these taxa suggests the presence of pelts, as bones of the paws often remain attached. Pelts of both species were traditionally used by Native Californians and may also have been another trade item (Lightfoot and Parrish 2009).

Deer have been an important resource for Native Californians for millennia, and deer are ubiquitous in the region. However, excavations from CA-MRN-202 recovered only one element identifiable to deer. Such low numbers may be attributable to at least three factors. First, deer may have been available but simply were not exploited at Toms Point. Second, deer may have been hunted, but their bones were so fragmented they were not identifiable. Third, deer may have been rare in the region during the time, possibly a consequence of habitat loss resulting from vegetation changes stemming from large-scale ranching operations beginning during the Mission Period.

Domestic ungulates, including pigs and cattle, are indeed more common in our results than wild ones. In addition, one sheep or goat, and one horse or donkey specimen were also recovered. Chickens are also present. Pigs are the most abundant domestic animal, and nearly all parts of the skeleton are represented, including numerous cranial and dental fragments (Figures 1 and 2). These patterns suggest that pigs were likely slaughtered onsite, as cranial remains are commonly discarded first as carcasses are processed. The presence of very young individuals suggests that pigs were raised rather than hunted, feral individuals. Cattle make up a much smaller percentage of the identifiable specimens. As seen in the faunal remains collected from mission and rancho settings, hide and tallow production usually focused on cattle, and documentary evidence suggests that hide and tallow sales were a major economic pursuit at Toms Point. However, this suggested production of these goods is weakened by the overall lack of cattle at the site. In fact, the Toms Point assemblage stands in stark contrast to the pattern of tallow production at missions, which regularly yield substantial proportions of cattle bones.

Particularly interesting is the large and species-rich avifaunal assemblage. Birds recovered from the site are numerous, and while chickens are present, the avifaunal assemblage comprises mostly wild fowl and seabirds. Most ducks recovered belong to the genus *Anas*. These are dabbling ducks, such as Mallards, Northern Shovelers, and Cinnamon Teal. These taxa outnumber diving birds, including diving ducks, grebes, loons, and cormorants. Dabbling ducks generally inhabit smaller bodies of water than do diving ducks, suggesting that the Toms Point occupants targeted such areas for hunting fowl, possibly using nets (Kelly 1978). Similarly, birds like the Pied-billed Grebe, which typically inhabit ponds and marshes, testify to the exploitation of smaller bodies of water. Other taxa such as pelicans and gulls were likely hunted using other methods. Only one raptor bone was recovered, that of a hawk (*Buteo* sp.). The bone is from the wing, suggesting that the animal was used for its feathers (Gifford 1967).

Beyond providing a window onto hunting strategies, the avifaunal assemblage provides a view on seasonal scheduling at Toms Point. The presence of scoter (*Melanitta* sp.), as well as the presence of other migratory birds species that winter in California, including the Snow Goose, Greater White-fronted Goose, and Canvasback, points to a likely winter occupation and the exploitation of migratory waterfowl.

Again, documentary evidence points to a summer occupation of the area:

> Tom's home was the rendezvous of all of the Indian tribes and it was not a difficult matter for him to keep them supplied with food…. During the *summers* of 1845–46, it was not an uncommon sight to see 1,000 Indians along the bay shore (Lauff 2009 [1916]; emphasis ours).

Taken together, the archaeological and documentary evidence support the idea that Toms Point was occupied year-round. Ongoing stable-isotope analysis of shellfish will help clarify the seasonal scheduling of resource acquisition.

In summary, analysis of the CA-MRN-202 faunal assemblage clearly shows the maintenance of hunting practices, as indicated by numerous wild species. Yet we also see the adoption of Old World domesticates in this context, particularly the emphasis on raising pigs. This incorporation of European "materials" by Coast Miwok is mirrored in other aspects of the CA-MRN-202 assemblage, such as evidence of modifying bottle glass into tools. The paucity of deer remains recovered, despite their reported abundance in the region, further points to an emphasis on domesticated animals, at least among terrestrial fauna. During an expedition around Tomales Bay in 1793, Felipe Goycoechea remarked that "chickens and pigs" had been left for him by another Spanish expedition (Wagner 1931:344). This comment suggests a long history of domestic animals in the region, for which the local populations may have developed a taste.

Economic endeavors at Toms Point during the 1840s through 1860s appear to have been varied, rather than exclusively dealing in the hide and tallow trade. However, it is possible that tallow producing areas at Toms Point simply haven't yet been recovered. Nevertheless, given the overall diversity of fauna recovered from Toms Point, it is likely that the occupants of this "trading post" maintained multifaceted interests.

CA-MRN-363

The vertebrate faunal assemblage from the much earlier CA-MRN-363 site is comparatively smaller. Invertebrates collected from this site—including numerous, whole clam shell valves—continue to be analyzed. Elk, sea otter, and Brandt's Cormorant comprise the identifiable and non-intrusive portion of the CA-MRN-363 faunal assemblage. Several mole and rodent remains were also recovered, but they are likely to be intrusive from modern contexts and therefore are not listed (Table 3).

Table 3. Identifiable vertebrate fauna recovered from Toms Point (CA-MRN-363). Analysis of the fish assemblage from this site is currently underway.

Taxon	Common Name	Number of specimens
Phalacrocorax penicillatus	Brandt's Cormorant	1
Talpidae	mole	3
Rodentia	rodent (indeterminate)	2
Geomyidae	gopher (indeterminate)	1
Thomomys talpoides	pocket gopher	10
Cervus canadensis	elk	1
Enhydra lutris	sea otter	1
Total		19

The mammal and avian faunal assemblages from CA-MRN-202 and CA-MRN-363 at Toms Point demonstrate the long-term exploitation of wild fauna from California's rich coastal environments. The diverse vertebrate faunal assemblage recovered from CA-MRN-202 illuminates both foodways and economic activities among the site occupants. These remains reveal a constellation of foodways influenced by indigenous hunting practices and new species introduced by European and American colonizers. The faunal remains recovered during excavations thus lend a more nuanced view on Native Californian decisions regarding subsistence practices and foodways in a changing landscape during and following California's Mission Period.

Acknowledgements

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Electronic walk-through cage for mountain lions

Walk Through to a New Era

by Quinton Martins and Neil Martin

Carnivore biologists find that the low densities and often cryptic habits of free-ranging large predators make their behaviors and ecology extremely challenging to understand. Data are often gleaned through GPS-collaring of animals in the wild. Such data are currently being gathered by ACR's research on mountain lions *(Puma concolor)* in Sonoma and Napa counties and used to develop effective habitat conservation and management strategies. This process requires the safe capture and handling of these magnificent animals. In order to obtain scientifically sound research results, capture methods should not have a negative effect on the study animals. Methods should also be efficient in terms of the rate and cost of captures. Despite the fact that animal capture by humans is an age-old activity, the techniques required by federal and state regulations should take into account advancements in technology that optimize animal welfare as well as improve efficacy within the context of the research.

Figure 1. Mountain lion cage trap set on a path (left) with detailed setting using stepping sticks with no treadle-plate (right).

In California, we have been limited by the state as to how mountain lions may be captured. Two primary methods, capture by hounds and by cage traps, are permitted, whereas a third, the use of foot cable restraints (foot snares), was banned in 1990. Because of the highly fragmented nature of the Sonoma County study area and the small sizes of land parcels, running hounds to "tree" a mountain lion is not practical, leaving cage trapping the only option. However, throughout the mountain lions' vast range in North and South America, cage trapping has been limited to using traps with bait. In areas where bait is scarce, prey is abundant, or conditions not suitable, capture success is significantly compromised.

In response to such difficulties, the ACR Mountain Lion Project developed a new, high-tech trapping method for mountain lion capture. The concept grew out of research previously conducted in South Africa by Quinton Martins (2010; The ecology of the leopard *Panthera pardus* in the Cederberg Mountains. PhD Dissertation, University of Bristol, UK). While trapping and radio-collaring leopards between 2005 and 2014, he used double-door walk-through box traps, placed on paths where leopards were expected to walk or had previously been recorded during camera trap surveys (Figure 1). Vegetation was used to camouflage the traps and to guide the animals into the traps. A fragrance

Advantages of Electronic Walk-Through Trap

- Use with choice of no bait or bait; or use as conventional single-door trap.
- Trap all-year round, with no seasonal limitations due to bait degradation.
- Improve trapping success where lions do not return to baited-sets or when lions are trap shy.
- Set trap timer to activate the cage only when capture teams are on standby.
- Set electronic sensors to target size-specific animals, increasing humaneness of the trap.

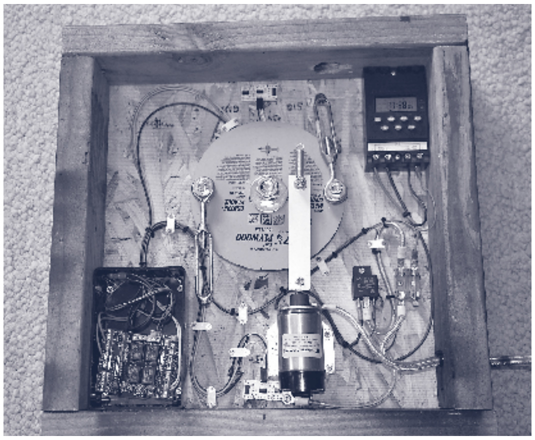

Figure 2. Actuator mechanism for electronic capture cage.

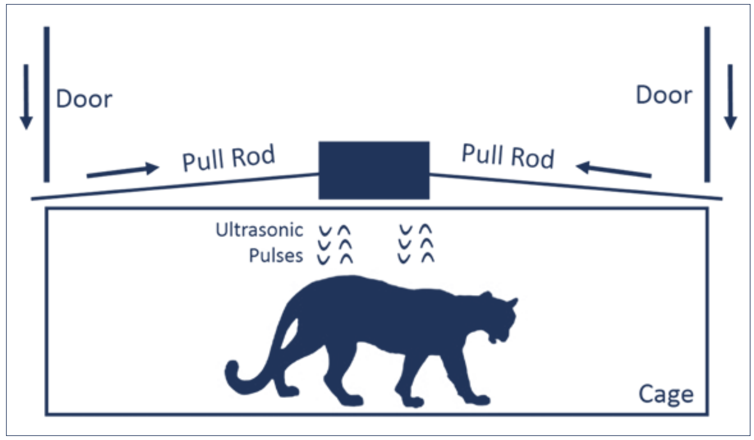

Figure 3. Mountain Lion cage operation.

such as a perfume or leopard scat was used on the centrally located treadle-plate in conjunction with diagonally placed stepping-sticks in front of either side of the treadle-plate (Figure 1). These measures were designed to break the momentum of the leopard and enhance the chance that it would place its foot on the treadle-plate, thereby triggering the trap (Figure 4).

Considering that leopards and cheetah *(Acinonyx jubatus)* have been repeatedly captured using this method, we believed the method could also be used to capture mountain lions. If so, the method would provide another useful tool for biologists when other trapping methods are considered less suitable or unavailable.

Going high-tech

The disadvantage of the manual treadle was having the trap triggered by non-target species such as badgers, small ungulates, and other mammals, despite weighting the treadle for leopards or mountain lions. Consequently, to avoid non-target captures in our mountain lion project, a simple, "high-tech" electronically operated cage was developed to improve efficacy while simultaneously minimizing trap management (Figure 2). For easier transport and handling, the cage was made in two parts, then connected in the field. A horizontal guide for a middle door insert acts as type of "crush-cage," forcing the cat into a smaller space for easier immobilization. The door is inserted as soon as the researchers arrive at the captured cat.

Figure 4. Quinton (in the cage!) and Neil setting up the trap in the field. Photo by Jim Codington.

How the trap mechanism works

The cage doors drop instantaneously when the "pull-rods" are pulled by high-powered 12-volt solenoid (Figure 3). To simplify the design, the pull-rods rebound after a timed delay, becoming the door-lock mechanism. For the electronic actuator we used ultrasonic range sensors installed at the top of the cage pointing downwards. By measuring the distance from the top of the cage to the animal, we could set it to trigger for mountain-lion sized animals only, minimizing the chance of triggering on a smaller animal such as a fox. We added a 12-volt timer to ensure we only power the trap during times when the capture team are on call. All components are housed in a single weatherproof case. Field set-up is extremely easy and involves setting the box that houses the actuator mechanism and timer on top of the cage in a center location and adjusting the actuator rods for the doors to rest on.

Proof of concept and benefits

To prove the concept worked, we first had to demonstrate to the California Department of Fish and Wildlife that mountain lions would walk through our cage (unset) and, second, that this trap was safe to use. We placed a trap on a suitable path and produced video evidence of mountain lions walking through. We then tested the trap on a Labrador dog, demonstrating that the mechanism worked by setting the sensors to safely trigger when the dog walked through the cage. In one week, we captured one adult male and one adult female mountain lion in the new trap (Figure 5).

The use of hounds to tree mountain lions in the semi-urban, fragmented landscape of our study area in Sonoma and Napa counties is not a viable option for lion capture. Effective baiting is limited to the cooler months when baits don't degrade as quickly. Bait procurement is challenging, and decomposition is exacerbated by excessive scavenger activity. Furthermore, lions have seldom returned to baits on the second night when traps were set, possibly due to the abundance or availability of prey. We therefore see this walk-through trap as an effective replacement for trapping mountain lions. Furthermore, with minor adjustments, this cage concept could be implemented in other studies, to safely capture multiple species such as bobcat, foxes, or even bears.

The new trap dramatically enhances the effectivenss of our our field research. We anticipate future design improvements, which include remote cage control and release of non-target species using small, motorized 12-volt winch. Image recognition software, where sensors are able to identify a species or even individual may be useful for certain studies.

Quinton Martins is the principal investigator and Wildlife Ecologist for ACR's Mountain Lion Project.

Neil Martin is the Marketing Director for Keysight Technologies, Santa Rosa, California, and is an electrical engineer by trade.

Figure 5. Female mountain lion captured in walk-through cage.

Visiting investigators Audubon Canyon Ranch hosts graduate students and visiting scientists who rely on the undisturbed, natural conditions of our preserves to conduct investigations in conservation science.

Dispersal vectors and risk assessment of noxious weed spread: medusahead invasion in California rangelands. Emily Farrer, University of California, Berkeley.

Context and scale of seagrass effects on estuarine acidification. Tessa Hill, Bodega Marine Lab, University of California, Davis.

The role of microbiota in mediating local adaptation and plant influence on ecosystem function in a marine foundation species. Melissa Kardish, University of California, Davis.

Interactions between marsh plants along a longitudinal gradient: the effect of environmental conditions and local adaptation. Akana Noto, University of California, San Diego.

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 non-motorized recreation on medium- and large-sized mammals in the San Francisco Bay Ecoregion. Michelle Reilly, Northern Arizona University.

Spatial and temporal variability in eelgrass genetic structure. Laura K. Reynolds, University of California, Davis.

An archaeological study of indigenous landscapes and social networks at colonial Toms Point, California. Tsim D. Schneider, University of California, Santa Barbara.

The wildlife photo index: monitoring connectivity and ecosystem health. Susan E. Townsend, Wildlife Ecology and Consulting/Pepperwood Preserve.

Sonoma County Vegetation & Habitat Mapping Program. Mark Tukman, Tukman Geospatial and Sonoma County Agricultural Preservation and Open Space District.

Paternity comparison of seeds sired by a variety of pollinators to Clarkia concinna. Kathleen Adams, University of California, Santa Cruz.

Aramburu Island Enhancement Project (propagation of Extriplex californica *from Toms Point).* Shannon Grover and John Takekawa, Richardson Bay Audubon Center and Sanctuary, Tiburon, California.

In Progress

Current projects by Audubon Canyon Ranch focus on the stewardship of preserves, ecological restoration, and issues in conservation science.

Bolinas Lagoon Heron and Egret Project. All heron and egret nesting attempts in Bolinas Lagoon have been monitored annually since 1967. The heronry at the Martin Griffin Preserve was abandoned in 2014, but we are continuing to track nest abundances and reproductive performance in the lagoon, including the active heronry near Bolinas.

Tomales Bay Shorebird Census. Since 1989, qualified birders have helped ACR to monitor the shorebird use in Tomales Bay. The data are used to investigate winter population dynamics, habitat values, and other topics. A paper on the benefits of tidal marsh restoration to shorebirds, by ACR's John Kelly and Emiko Condeso, was featured as the cover article in the July 2017 issue of *Restoration Ecology*.

Tomales Bay Waterbird Survey. Since the winter of 1989–90, teams of qualified observers have conducted winter waterbird censuses from survey boats on Tomales Bay. The results provide information on the habitat values and conservation needs of more than 50 species.

North Bay Counties Heron and Egret Project. Annual monitoring of all known heron and egret nesting colonies in five northern Bay Area counties began in 1990. Results are used to measure the effects of climate change, impacts of human disturbance, and the status of herons and egrets in the San Francisco Bay area. ACR's online regional atlas and Google-Earth program show the locations and status of individual heronries (www.egret.org/atlas).

Heron and Egret Telemetry Project. We are using GPS telemetry to track the movements, regional landscape use, and foraging behaviors of Great Egrets throughout the Bay Area and beyond. The project will determine how key habitat features needed by these top wetland predators can be used to advance wetland conservation planning and restoration.

Hydrogeomorphological Assessment of Martin Griffin Preserve Canyons. ACR is working with Kamman Hydrology & Engineering to characterize watershed conditions in MGP's four canyons, incorporating climate change and linkages with the Bolinas Lagoon ecosystem.

Cape Ivy Control. ACR stewardship staff have been implementing a phased approach to the control of non-native, invasive cape ivy *(Delairea odorata)* in the riparian corridor of Volunteer Canyon.

Golden Gate Biosphere Reserve. ACR's Martin Griffin Preserve, a member of the United Nations Golden Gate Biosphere Preserve since the 1990s, will now become part of the "core area" of this regional partnership.

Monitoring and Control of Non-Native Crayfish. Bouverie Preserve staff and volunteers are continuing to control invasive signal crayfish *(Pacifastucus lenisculus)* in Stuart Creek to reduce the impacts on native amphibians, steelhead, and other species.

Biological Species Inventory. Resident biologists maintain ongoing inventories of native plant, animal, and fungal species known to occur on ACR lands.

Non-Native *Spartina* and Hybrids. ACR is continuing to collaborate with the San Francisco Estuary Invasive Spartina Project to coordinate and conduct field surveys and removal of invasive, non-native *Spartina* in Tomales Bay.

Perennial Pepperweed in Tomales Bay. We are conducting baywide surveys of shoreline marshes and removing isolated infestations of invasive, non-native pepperweed *(Lepidium latifolium)*, known to quickly cover estuarine wetlands, compete with native species, and alter habitat values.

Saltmarsh Ice Plant Removal. After eradicating non-native ice plant from ACR's Toms Point on Tomales Bay, we are continuing to remove resprouts, along with occasional new patches introduced from other areas by high tides and currents.

Vernal Pool Restoration. We are monitoring native plants in Bouverie Preserve's vernal pools, including a patch of federally endangered plant Sonoma sunshine *(Blennosperma bakeri)* that ACR restored in 2009, and controlling invasive plants using manual removal and prescribed cattle grazing.

Yellow Starthistle at Modini Mayacamas Preserves. Sherry Adams is investigating the responses of native and non-native grassland plants to the removal of non-native yellow starthistle *(Centaurea solstitialis)*. She has also developed guidelines to reduce the spread of this invasive pest plant.

Invasive Species Management at Modini Mayacamas Preserves. We collaborate with volunteers on early detection, monitoring, and elimination of wildland weeds such as distaff thistle *(Carthamus lanatus)* and barbed goatgrass *(Aegilops triuncialis)*. For widespread species, such as milkthistle *(Silybum marianum)* and yellow starthistle *(Centaurea solstitialis)*, we use containment to limit their spread into new areas.

Songbirds of the central Mayacamas Mountains. To measure the breeding-bird habitat relationships, we are conducting point counts from the bottom to the top of Pine Flat Road, near Healdsburg, including ACR's Mayacamas Mountains Sanctuary. The work is augmented by investigations at Modini Ingalls Ecological Preserve. Interested birders who can identify birds by ear are encouraged to contact ACR's Cypress Grove Research Center.

Rosy Sandcrocus. At Bouverie Preserve, ACR staff are testing management techniques, including the use of prescribed fire, to control rosy sandcrocus *(Romulea rosea)*, an invasive forb with a potential to severely degrade California open spaces and rangelands.

Harding Grass Meadow Restoration. ACR's Fujita Research Fellow Dylan Gallagher is working with ACR staff at Bouverie Preserve to test the effectiveness of burning, mowing, solarization, and planting of native grass seeds to restore a grassland dominated by invasive Harding grass *(Phalaris aquatica)*.

Mountain Lion Project. ACR is tracking the movements of mountain lions fitted with GPS satellite collars to study wildlife corridors, regional abundance, and the conservation needs of mountain lions in areas east of Highway 101 in Sonoma County. As part of this effort, ACR is collaborating with Sonoma Land Trust, Sonoma County Regional Parks, California State Parks, and other members of the Wildlife Observers' Network Bay Area (WONBA) convened by Pepperwood Preserve.

Ecological Restoration of the Inverness Shoreline. After removing non-native vegetation and all buildings on property donated by Helen McLaren, ACR is restoring two acres of habitat with a natural gradient of riparian and tidal wetlands.

Wet Meadow Restoration at Ferguson Spring, Modini Mayacamas Preserves. ACR is removing invasive vegetation and planting native species along an intermittent waterway that has become incised due to the placement of an historic road that is no longer in use.

McDonnell Creek Restoration, Modini Mayacamas Preserves. We are removing an unused road crossing over a creek and restoring the channel to protect downstream creek habitat and stabilize the site with local native plants.

THE ARDEID

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The Watch

Volunteers for ACR research or habitat restoration projects since *The Ardeid* 2016. Please call (415) 663-8203 if your name should have been included. **Project Classifications: B**—Bouverie Stewards ■ **C**—Songbirds of the Central Mayacamas ■ **H**—Heron and Egret Project ■ **MG**—Martin Griffin Preserve Stewards ■ **ML**—Mountain Lion Project ■ **MP**—Modini Mayacamas Preserves Stewards ■ **R**—Other ACR Research and Stewardship ■ **S**—Tomales Bay Shorebird Census ■ **W**—Tomales Bay Waterbird Census

Nancy Abreu (H), Bob Adhers (B, MP), Steve Albert (H, S, W), Sarah Allen (W), Mae Barrett (S), Bob Battagin (S), Tom Baty (H, W), Anne Baxter (C), Gordon Beebe (C, S, W), Seamus Begley (MP), Gordon Bennett (W), Patti Blumin (H), Ellen Blustein (S), Janet Bodle (H, S), Janet Bosshard (H, MP), Bill Bridges (H), Denice Britton (H), Justin Brown (MP), Ron Brown (H), Brianne Brussee (H), Phil Burton (H), Denise Cadman (H), Debbie Carpenito (MP), Ann Cassidy (H), Joanna Castaneda (H), Joanne Castro (H), Penny Chambers (MP), Chip Chipman (R), Richard Cimino (H, S), Julie Clark (MP), Margaret Colbert (S), John Comisky (H), Judith Corning (S, W), Bob Cox (B), Mishella Craddock (B), Nan deLormier (MP), Mark Dettling (W), Patricia DiLuzio (S), Amanda Dunker (MP), Daniel Edelstein (H), Tim Engel (MP), Chris Engel (B), Janeann Erickson (H), Tiffany Erickson (H), Jules Evens (W), Eric Fessenden (B, MP), Ginny Fifield (ML, MP, R), Binny Fischer (H, W), Ime Fitzgerald (ML), Mary Anne Flett (S), Jobina Forber (B), Ruth Friedman (H), Denny Fujita (B, MP), Tom Gaman (S), Juan Garcia (C, S, W), Anthony Gilbert (S), Carolyn Greene (C, S), Kelly Grieve (MP), John Guilfoy (MP), Kathy Hageman (H), Bob Hahn (B), Madelon Halpern (H), Lauren Hammack (H), Linda Hammer (MP), Roger Harshaw (W), Mac Hartford (MP),Luanna Helfman (C, H, S), Hugh Helm (B), Earl Herr (B), Howard Higley (W), Kim Horell (MP), Lisa Hug (C), Connor Jacobson (ML), Richard James (R), Lorraine Johnson (MG), Jason Jordan (H), Tom Joynt (B), Gail Kabat (W), Kate Keiser (H), Joan Lamphier (H, S, W), Brett Lane (H, MP), Toni LeCompte (MP), Stephanie Lennox (H), Robin Leong (H), Peter Leveque (MP), Leslie Lihou (MP), Iris Lombard (S), John Longstreth (S, W), Carolyn Longstreth (S, W), Mike Mahoney (MP), Ron Mallory (H, W), Meg Marriott (H), Susan Maxwell (MP), Mark McCaustland (H, W), Melinda McCutcheon (MP), Sarah Millus (H, W), Jim Moir (ML), Ian Morrison (C), River Mortenson (MP), Gerry Mugele (H), Kathleen Mugele (H, S), Dan Murphy (S), Sheryl Nadeau (H), Len Nelson (H), Don Neubacher (W), Wally Neville (H), Susan Nuernberg (B), Jeremy Nusser (MP), Rebecca Olsen (C, W), Trent Orr (W), Tony Paz (MG), Don Pendleton (C), Sean Peterson (S), Margaret Petrie (H), Todd Plummer (S, W), Carol Poole (H), Penny Proteau (H), Louis Ptak (W), Peter Pyle (S), Greg Raynor (H), David Reichel (H), Ken Reid (MP), Louise Riedel (B), Julie Roemer (H), Mary Rooney (S), Susan Rose (MP), Glenda Ross (B), John Rudell (MP), Ellen Sabine (H), Wendy Schackwitz (H), Don Schmidt (MP), Ken Schneider (S), Lynn Schofield (S), Peter Schurch (MP), John Schwonke (B), Victoria Seher (H), Mimi Shaul (ML), Deb Sheppard (H), Ann Shippey (MP), Richard Shipps (B), Beckie Simmie (S), Paul Skaj (W), Elliott Smeds (MP), Grant Snetsinger (B), Jackie Sones (W), Jude Stalker (W), Amy Stanfield (ML), Michelle StClaire (MP), Lang Stevenson (S), Daniel Stone (ML), Kandice Strako (W), Kate Symonds (H), Phoebe Tanner (H), Francis Toldi (W), Vernon Vale (MP), Village Charter School (MP), Tessa Wardle (S), Richard Wasson (MP), Anna Weinstein (W), Alan Wight (C), Adele Wikner (H), Larry William (MP), Ken Wilson (C, W), David Wimpfheimer (S, W), Suzie Winquist (W), Judy Withee (B), Patrick Woodworth (C, H, S, W), John Worden (MP)

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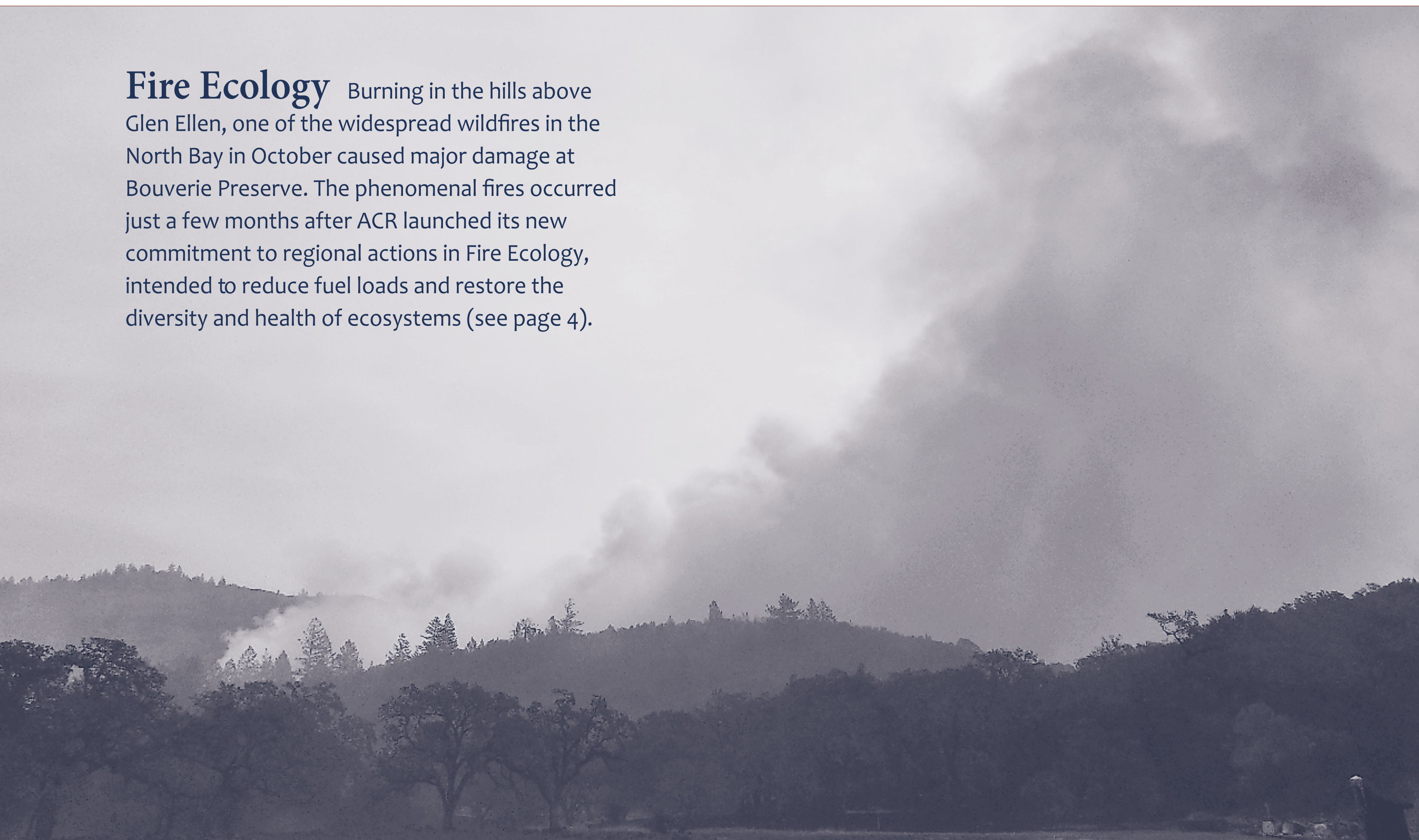
THE ARDEID

Conservation Science and Stewardship at Audubon Canyon Ranch



Fire Ecology Burning in the hills above Glen Ellen, one of the widespread wildfires in the North Bay in October caused major damage at Bouverie Preserve. The phenomenal fires occurred just a few months after ACR launched its new commitment to regional actions in Fire Ecology, intended to reduce fuel loads and restore the diversity and health of ecosystems (see page 4).