Conservation Science and
Habitat Protection at
Audubon Canyon Ranch

THE ARDEID

2015

In this issue

Cover: *Mountain Lion is one of many species that benefit from wildlife corridors. Photo by Phillip Colla.*

Ardeid masthead: *Great Blue Heron ink wash painting by Claudia Chapline.*

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AUDUBON CANYON RANCH
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conservation in action

The Watch

Volunteers for ACR research or habitat restoration projects since *The Ardeid* 2014. Please call (415) 663-8203 if your name should have been included. **Project Classifications: B**—Bouverie Stewards ♦ **C**—Cypress Grove Research Center Office Volunteers ♦ **H**—Heron and Egret Project ♦ **M**—Modini Ingalls Ecological Preserve Breeding Bird Assessment ♦ **MA**—Pine Flat Road Breeding Bird Survey ♦ **MG**—Martin Griffin Preserve Stewards ♦ **R**—habitat protection and restoration projects ♦ **S**—Tomales Bay Shorebird Census ♦ **W**—Tomales Bay Waterbird Census

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Acting beyond property boundaries to hold back a non-native Spartina invasion

Careful Stitches

by Emiko Condeso and Ingrid Hogle

In the late 1800s, oysters from the Atlantic coast steamed into Washington state's Willapa Bay by train and cargo ship, packed securely in "nests" of smooth cordgrass, *Spartina alterniflora*. Although not intentionally introduced into the bay, the cordgrass took deep root—literally and figuratively—and by the year 2002 had spread to cover approximately 15,000 acres of mudflat in Willapa Bay (Washington State Department of Ecology 2015). This rapidly spreading invader has had dramatic impacts on the Willapa Bay tidelands.

Spartina alterniflora forms large, circular patches of densely packed stems that slow the flow of water and allow sediments to accumulate, raising the elevation of the marsh and converting mudflat into much higher and drier marshland. Meadows of *S. alterniflora* can clog channels and increase the risk of flooding, as well as dominate mudflat habitat to the exclusion of shorebirds, waterbirds, anadromous fishes, and other wildlife that would utilize it for foraging and for refuge from predators. In addition to impacts on wildlife, invasive *Spartina* threatens anything that relies on open mudflat and waterways, including mariculture operations. The impacts of this invasion were so severe that in 1995 the Washington State Legislature declared the *Spartina* invasion an "environmental emergency," threatening both the ecology and economy of the state, and assigned a high priority to its control.

Although one might think the story of the *Spartina* invasion in Willapa Bay a straightforward ecological lesson, the initial spread of invasive *Spartina* happened slowly, not ramping up to alarming rates until the 1980s. So in the early 1970s, seemingly unaware of the potential environmental damages, an employee of the United States Army Corp of Engineers planted *S. alterniflora* as part of a marsh restoration project adjacent to Alameda Creek in San Francisco Bay (Faber 2000). *S. alterniflora* was further spread throughout the estuary through plantings at other project sites, and at each new location it seemed to outcompete its native congener, California cordgrass *(Spartina foliosa)*. But something much more insidious than simple competitive advantage was at work.

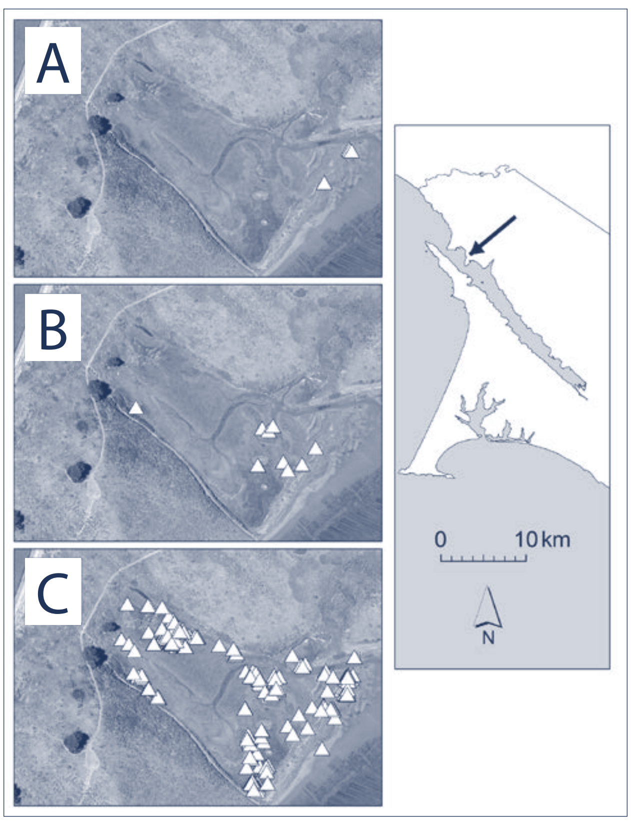

Figure 2. The distribution of *Spartina densiflora* clones at Toms Point Marsh, in Tomales Bay, Marin County, California (indicated by the arrow in the location map). *S. densiflora* clones are indicated by open triangles (some symbols overlap): (A) four individual plants were mapped and removed in 2001; (B) ten small individual plants were mapped and removed in 2014; (C) 285 plants were removed from 2001 through 2014. Map data provided by the California State Coastal Conservancy, San Francisco Estuary Invasive Spartina Project.

INVASIVE SPARTINA PROJECT

Figure 1. Non-native *Spartina densiflora* clones removed during regular annual monitoring are smaller than those that were removed in the early days of invasion management. Julia Stalker with a relatively small individual—but one of the larger clones removed from Toms Point Marsh in 2008.

Daehler and Strong (1997) found natural hybrids between invasive *S. alterniflora* and the native *S. foliosa*. Many of the hybrid plants were larger and more robust than their parents, and also reproductively superior (see box—Hybrid Swarm). These hybrid effects strongly magnify the potential impacts of non-native *Spartina* invasion. As a result, the story of *Spartina* invasion in the San Francisco Estuary is similar to its invasion in Willapa Bay, but with an alarming difference—the very real threat of local extinction of the native *S. foliosa* from the combined effects of competitive exclusion and genetic pollution (Ayers et al. 2003).

Protecting Tomales Bay

In 1999, the first invasive *S. densiflora* (dense-flowered cordgrass; Figure 1, box—*Spartina densiflora*) was found on Tomales Bay. California's answer to the *Spartina* invasion was the formation of the Invasive

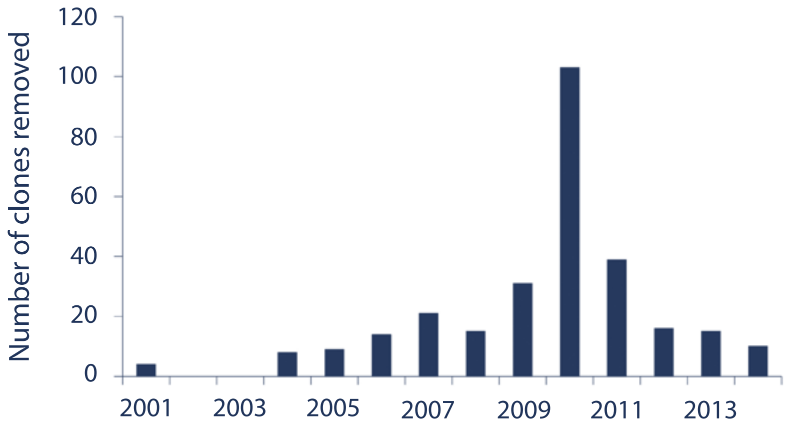

Figure 3. The number of *Spartina densiflora* clones removed each year at Toms Point Marsh. No survey or treatment data were available for the years 2002 and 2003.

Spartina Project (ISP; www.spartina.org), established by the California State Coastal Conservancy and U.S. Fish and Wildlife Service. ISP's mandate includes the development and implementation of a coordinated approach to managing the four species of introduced, invasive *Spartina* in San Francisco Bay. In 2001, ACR collaborated with ISP and other groups to begin monitoring and treatment in the highly vulnerable Marin County coastal wetlands of Bolinas Lagoon, Drakes Estero, and Tomales Bay (Figure 2). Although not within the San Francisco Estuary, these areas are particularly at risk of invasion because of their proximity to the Golden Gate and their importance to stands of native *S. foliosa*.

In 1999, the first invasive *S. densiflora* (dense-flowered cordgrass, see box—*Spartina densiflora*) was found on Tomales Bay. In 2001, a single *S. alterniflora* clone was found in Bolinas Lagoon and, in 2002, isolated patches of S. *alterniflora* were found in Drakes Estero. Fortunately, the lessons from earlier invasions led to a swift response by local biologists and stakeholders, and collaborative action prevented significant expansion of these infestations.

ACR continues to play an active role in managing the threat of non-native *Spartina* in Tomales Bay, on and off our sanctuaries, in collaboration with ISP. Early on, ISP helped to organize local monitoring by providing training in identification, mapping, and treatment to local landowners, oyster growers, and biologists, including ACR and collaborators from the Point Reyes National Seashore.

Working together, ISP and partners identified the most vulnerable areas and developed a protocol for annual surveys and removals. Today, ISP continues in this role, providing expert support in the field. They also maintain and readily share the data from all surveys with partners, keeping quality-controlled records that are critical for understanding the state of the invasion and the efficacy of management actions. For landowners, this open, collaborative approach greatly simplifies the difficult process of managing an invader that gives no heed to property boundaries and is frequently dispersed at scales far beyond most individual landholdings.

The ready movement of *Spartina* seeds on the tides and the broad mobility of its genetic material via wind-blown pollen forced an early understanding that coordinated, baywide management was necessary—even in a system where invasions occur only sporadically, such as Tomales Bay. Simply keeping some properties free of invasive *Spartina* and hybrids could not guarantee that others would not be invaded and become new sources of propagules. Despite this risk, examination of the invasion process at a single property provides an interesting illustration of how annual, moderate efforts—the proverbial "stitch in time"—can successfully hold back a more widespread invasion.

At ACR's Toms Point Preserve, in 2001, four *Spartina densiflora* clones were removed from the outer reaches of the marsh (Figure 2A, Figure 3). The largest clone was approximately 0.7 m in diameter, indicating several seasons of growth. In subsequent years, similarly small numbers of plants were removed annually until 2010, when a dramatically larger number of seedlings were found and quickly removed (Figure 3). It is unknown what caused this increase in new seedlings, although the seasonal timing of seed set can be highly variable, and the timing of removals in 2009 may have allowed more seed to set than usual. After 2011, the number of plants removed each year dropped back to earlier, lower levels, and, in 2014, only 10 small plants were removed (Figures 2B, 3, and 4).

As of 2014, the only known invasive *Spartina* on Tomales Bay occurred at two locations—Marshall Cove (near Hog Island Oyster Company) and Toms Point, both on the east shore of the bay. Figure 2C illus-

Hybrid Swarm

Spartina alterniflora is a vigorous competitor, yet hybrid offspring that result from cross-breeding with the native *Spartina foliosa* can be superior to their parent plants in both growth and reproduction. *S. alterniflora* x *foliosa* hybrids can self-fertilize and produce copious amounts of pollen and seed. The flowering times of hybrids overlap with those of their parent species, so they can create viable seed from either hybrid or pure parent plants. Over time, this crossing and backcrossing results in a hybrid "swarm" of extremely vigorous plants. Because of hybrid reproductive advantages, stands that were once dominated by native *S. foliosa* can be rapidly converted to hybrid *S. foliosa* x *alterniflora* meadows. The hybrid plants are an even greater threat to mudflat habitat than pure *S. alterniflora,* because most hybrids are larger and more robust and can dominate an expanded range on the mudflat (lower and higher tidal elevations than the parent plants). Their dense pattern of stem and root growth readily accretes sediment and can change the architecture of the marsh. Hybrid seeds germinate at a high rate relative to native *S. foliosa* seeds, and as more and more native *Spartina* is replaced by hybrid *Spartina* plants, the expansion rate is predicted to increase. According to Ayers and others (2004), the "simple end point of this process is the extinction of *S. foliosa*." This ecosystem conversion could have far-reaching consequences—from the obvious structural changes to a more subtle "trophic shift" in the composition of the food base supporting fishes, birds, and other wildlife (Levin et al. 2006).

INVASIVE SPARTINA PROJECT

Figure 4. *Spartina densiflora* clone being mapped in Toms Point Marsh and sampled for genetic testing. This plant was removed in 2001.

trates what Toms Point Marsh might have looked like if none of the *S. densiflora* had been removed since 2001. Although little data are available on the patch expansion rates of *S. densiflora*, it is likely that the individual plants shown in Figure 2C would have grown considerably into large patches with extensive cover.

Ongoing challenge and commitment

In San Francisco Bay, areal coverage of *S. densiflora* increased five-fold in 25 years, and plants dispersed tens of kilometers from the original sites of introduction (Ayers et al. 2004). Toms Point is located approximately 2 km from the large mudflat at Walker Creek Delta and less than 20 km from the newly restored Giacomini Wetlands. These areas are of particular importance to wintering and migrating shorebirds and have been protected by the continual collaborative efforts to manage the current *Spartina* invasion on Tomales Bay. Constant surveillance is required to catch newly established infestations of non-native *Spartina*, which could rapidly degrade the quality of open mudflat feeding areas needed by shorebirds.

While Tomales Bay and, especially, the San Francisco Estuary, may never be entirely free of invasive *Spartina*, continued efforts may serve to contain the current population and eradicate the phenotypes that cause the greatest negative impacts. Particularly at risk are the 550+ acres of newly restored tidal marsh in the Giacomini Wetlands, at the southern end of the bay. In addition to threatening the recently restored mudflats, an invasive "landscape architect" such as *S. densiflora* could easily alter the hydrology of the wetlands and compromise the restoration goals. Indeed, new restoration sites are notoriously vulnerable to invasions. Cogswell Marsh and Oro Loma Marsh on the east side of San Francisco Bay were rapidly taken over by invasive *Spartina* shortly after they were restored (O'Brien 2000).

Carefully walking the marshes each year and removing any non-native *Spartina* we find is critical to maintaining the ecological health of Tomales Bay. The success of such efforts depends on cultivating deep partnerships with like-minded organizations, neighbors, and volunteers. Engaging in such collaborative stewardship facilitates creative thinking and shared efforts over large areas, which will benefit the entire estuary. We welcome volunteers who are willing to learn to identify *Spartina* species and search the Tomales Bay tidelands on foot or by kayak. If you are interested in applying your expertise to our annual Tomales Bay *Spartina* survey, please contact Emiko Condeso at emiko@egret.org. Your efforts will contribute to the health of sensitive tidal marshes throughout the Tomales Bay ecosystem.

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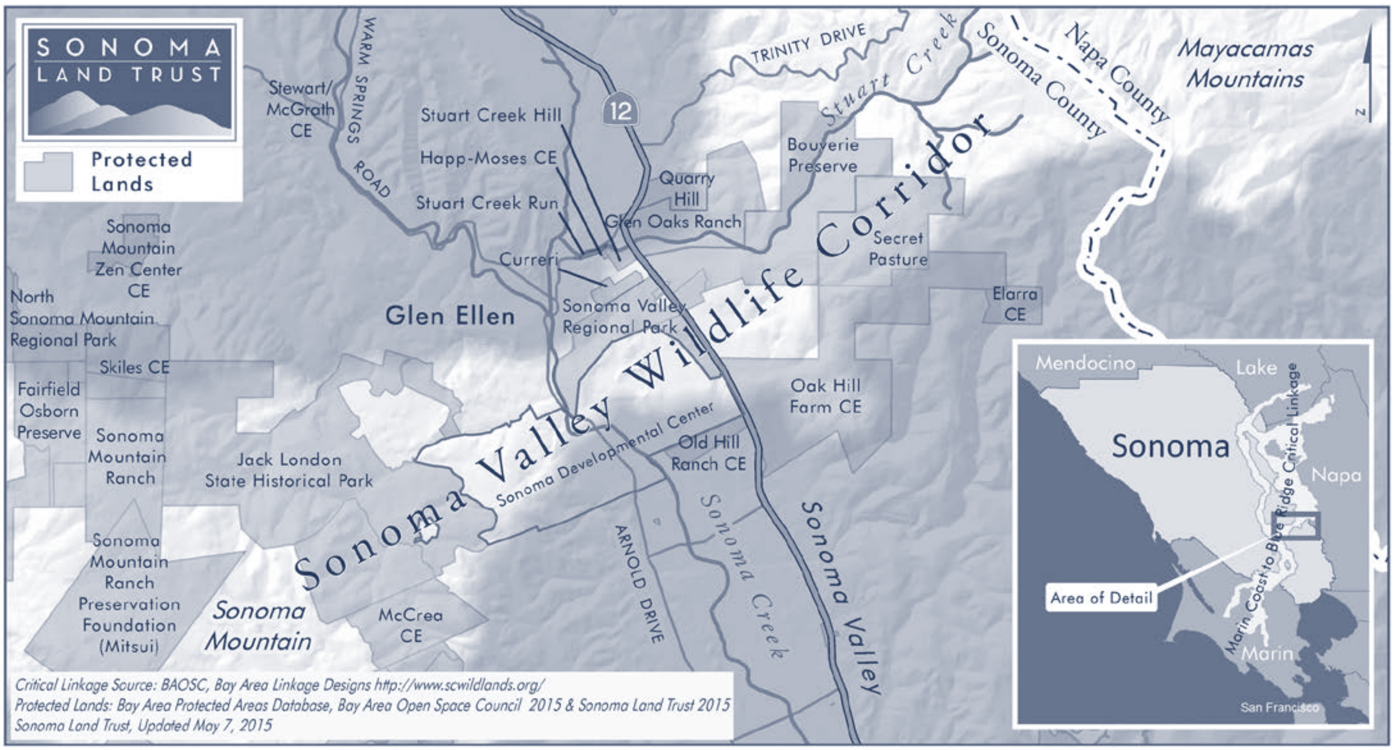
Spartina densiflora

Of the four non-native species of *Spartina* that are of concern in the San Francisco Estuary, the second most numerous (after *S. alterniflora*) is dense-flowered cordgrass, or *Spartina densiflora*. Originally from Chile, *S. densiflora* was introduced into California in the 1800s. It arrived in the San Francisco Bay Area much later, through an accidental planting:; the species was misidentified as an ecotype of native *S. foliosa* and was included in a marsh restoration in Corte Madera, Marin County (Faber 2000). *S. densiflora* grows in dense clumps, which expand vegetatively. It is also a prolific producer of seeds, and expansion of *S. densiflora* patches often comes from seedlings rather than by production of tillers (Jesús Castillo, Universidad de Sevilla, personal communication). *S. densiflora* produces more seed and has higher seed viability than *S. alterniflora* (Kittelson and Boyd 1997). Its seeds are dispersed to new areas by floating on the tides. Like *S. alterniflora,* it alters mudflat habitat by accreting sediment, sometimes forming "intertidal lands," blocking drainage, increasing elevation, and building up the margins of sloughs, resulting in altered plant and animal communities. *S. densiflora* is currently the only species of invasive *Spartina* that has been found in Tomales Bay. It is known to hybridize with the native *S. foliosa*,; however, these hybrids are apparently clonal perennials and do not produce viable seed (Ayers et al. 2008). Whether or not the hybrid *S. densiflora* persists in our tidal wetlands depends on the success of the eradication efforts throughout its introduced range.

ACR's regional habitat corridor partnerships in the Sonoma Valley

Staying Connected

by Jeanne Wirka



J. KINYON / SONOMA LAND TRUST, MAY 2015.

Figure 1. The Sonoma Valley Wildlife Corridor and ACR's Bouverie Preserve (upper center; east of Highway 12).

Conservation ecologists have long recognized that habitat fragmentation is a major threat to biodiversity and, therefore, that connectivity among blocks of habitat is critical for ecosystem health. Over the past several decades, a focused branch of ecology has emerged to study the effectiveness of landscape-based habitat corridors (also known as "wildlife corridors," "movement corridors," or "linkages") in allowing animals to safely disperse from one area to another to find food and water, escape predators, mate, or locate other important resources (Hilty et al. 2006). Corridor ecologists are concerned with measures such as gene flow, landscape permeability, and the scale at which different species of animals traverse the landscape.

Habitat corridors are increasingly being evaluated not only for their role in wildlife movement, but for their value in increasing ecosystem resilience under a rapidly changing climate. Habitat corridors, for example, might serve as possible resettlement routes or refugia for animals and plants adapting to climate change. In this light, it is not only the increased connectivity between patches of habitat that matters, but also the potential benefits of enhanced diversity of topography, elevation, and microclimate (See for example Merenlender and Gray 2015; Townsend and Masters 2015).

Of particular concern, whether for individual species survival or multi-species climate adaptation, are areas where connectivity between large blocks of habitat is reduced to narrow "pinch points" that severely constrict or otherwise limit wildlife movement and/or propagule dispersal. ACR's Bouverie Preserve, in the heart of Sonoma Valley, sits precisely in the middle of one such pinch point linking important blocks of oak woodland habitat to the east and west of State Highway 12. Where the Bouverie Preserve and the Sonoma Land Trust's Glen Oaks Ranch border the eastern side of Highway 12, the Sonoma Valley Wildlife Corridor is reduced to just three-quarters of a mile wide (Figure 1). To further ACR's commitment to regional conservation action—and because of the key role of Bouverie Preserve as part of this corridor—Resource Ecologist Jennifer Potts and I are participating in a number of local collaborations and research efforts aimed to protect and enhance habitat values throughout this part of the Sonoma Valley.

The Sonoma Valley Wildlife Corridor spans approximately five miles connecting

JEANNE WIRKA

Figure 2. Kara Caselas of the Sonoma Land Trust installs a wildlife camera used to document wildlife presence at the Bouverie Preserve, while consulting biologist Dr. Susan Townsend looks on.

Sonoma Mountain on the west side of valley to the crest of the Mayacamas Mountains to the east (Sonoma Land Trust 2014). It is part of the much larger Blue Ridge–Marin Coast Critical Linkage identified by the Critical Linkages Project (Penrod et al. 2013). The corridor is home to a uniquely rich flora and array of vegetation types dominated by oak woodlands—the most biologically diverse habitat type in California. Yet only about half of the 10,000 acres within the corridor are comprised of protected land.

In 2013, the Sonoma Land Trust (SLT) initiated the Sonoma Valley Wildlife Corridor Project, with funding from the Gordon and Betty Moore Foundation and Resources Legacy Fund, to address the specific, serious risk that this vital-but-constricted connection could be lost due to conversion of oak woodland habitat to vineyards and exurban development.

As a member of SLT's Corridor Technical Advisory Group and the Wildlife Observers Network-Bay Area (WONBA), ACR is working to identify best management practices for the Bouverie Preserve, with regard to the protection of corridor values. For example, we are assessing wildlife access through our property, removing and/or modifying fencing, limiting night-time lighting, and participating in two wildlife camera studies.

Many corridor ecologists use a set of target species with specific habitat needs in order to delineate the lands most critical to maintain habitat linkages. For example, in delineating the Blue Ridge–Marin Coast Linkage, researchers with the Critical Linkages Project used mountain lion and badger (Penrod et al. 2013). Of course, documenting exactly how and whether the target species and other wildlife actually traverse the landscape is much more difficult.

Our current wildlife camera research at the Bouverie Preserve, in partnership with the Felidae Conservation Fund and SLT, has documented over 20 species and hundreds of individual animals large enough to trigger the motion-activated cameras (Figure 2). Among these are several resident female mountain lions with kittens at the Bouverie Preserve as well as at least one male that we know traverses the landscape from the chaparral in the upper elevations of the preserve to the oak woodlands that border Highway 12 (Figure 3).

An exciting possibility for additional research includes ACR's emerging partnership with the Snow Leopard Conservancy, based in Sonoma, which is working with the California Mountain Lion Conservation Program of the California Department of Fish and Wildlife to develop a project to, among other goals, document the local movement of individual mountain lions within the corridor.

ACR is also participating in a coalition of organizations concerned about Governor Brown's proposal to close the Sonoma Development Center (SDC), a residential care facility serving patients with severe developmental disabilities, located on 945 acres of State-owned land on the western edge of the corridor (Figure 1, center). About three quarters of the land (700 acres) is open space recently determined to be highly permeable to wildlife and therefore of critical importance to the function of the corridor (Merenlender and Gray 2015). If the State were to sell off this valuable real estate without safeguards to protect the open space, it would be extremely vulnerable to agricultural conversion (think Sonoma County wine) or exurban development. To prevent this, and to maintain appropriate levels of service for the Center's extremely vulnerable population, the SDC Coalition is working on a plan to retain care services for the remaining residents, explore other complementary and appropriate uses within the footprint of the SDC facilities, permanently protect the open land on the property, and expand public access and recreation opportunities that are compatible with the protection of the property's conservation values (SCAOPD 2015).

Of particular value is the fact that the corridor as a whole, nestled between the coastal fog belt and the drier inland valleys, connects a valuable diversity of habitat types. This may allow species to shift their ranges in response to climate change, improving the resiliency of the entire ecosystem. Indeed, a recent analysis using a range of climate metrics found that the diversity of climatic conditions in habitats connected to this corridor are high compared to other corridors in the region and it is predicted to increase over time (Merenlender and Gray 2015). As a central and permanently protected section of the corridor, the Bouverie Preserve is well-situated to provide important long-term monitoring data to measure climate adaptation within the corridor.

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Jeanne Wirka is ACR's Director of Stewardship.

ACR PHOTO

Figure 3. A mountain lion utilizes the Sonoma Valley Wildlife Corridor, travelling between ACR's Bouverie Preserve and SLT's Glen Oaks Ranch.

Phenology, culture, and software for stewardship, education, and research

Bad-boy Salad

by Dave Self

In the scientific discipline known as "phenology," observers track the cycles of plants and animals as driven by daily, seasonal, and annual cycles of the sun and moon, which affect day-length, temperature, precipitation, and other conditions that influence the growth, development, and "behavior" of plants and animals. Volunteers at ACR preserves are beginning to document the flowering and fruiting seasons for a handful of species as part of a nationwide citizen-science effort facilitated by the USA National Phenology Network (www.usanpn.org). These projects seek to document the responses of plants to changing climate, driven by concerns that climate and climate zones may be shifting faster than species or communities can adapt or relocate.

In addition to scientific documentation of biological cycles, folk traditions have long been tracking seasonal changes in plant growth and development. Old aphorisms link seasonal occurrences, such as the first flowering of a species, with actions such as tilling, planting, pruning, and harvesting. From old farming almanacs, for example, you may have learned to "plant your potatoes when shadbush blooms,"—and to go fishing for shad, too, as that's also when the shad run up the rivers. You might also know to "plant your peas when your daffodils bloom," to "plant your tomatoes when lily-of-the-valley is in full bloom," or to "plant your corn when oak leaves are the size of a squirrel's ear" (Greayer, R. 2011, Folk Wisdom & Applied Phenology, pithandvigor.com).

In California cultures, each basket-weaver watches for a specific flower or other cue, such as the first warming wind of spring, to signify the time to collect willow. This is a very narrow window, when the willow resprouts are best for basketry: long and supple, but before buds and side-shoots strengthen or lengthen. Shellfish gathering too, has its season. In Pomo traditions, for example, a "song that came from elderberry" teaches that you shouldn't collect shellfish when elderberry is in flower or fruit. This bit of "interspecies wisdom" helped the Pomo avoid potential poisoning from red tides (Jones, S. A. 1999; Simply Living: The Spirit of the Indigenous People, New World Library, Novato, CA).

The folk phenologies of cultures native to California helped people interact with hundreds of plant species, in intimate tending relationships—in each week of each season—to promote the growth of basket sprouts, greens and seeds, and browse for deer; to open parts of the marsh for ducks and geese and tule-potatoes (*Sagittaria* species); and for many other purposes (Anderson, K. 2005; Tending the Wild, UC Press, Berkeley, CA). Pomo basket-weaver, Edward Willie calls these traditions "wildland permaculture." Others use the term Traditional Ecological Knowledge or TEK. Anderson, Willie, and many others believe that TEK and related management practices sustained rich biodiversity and the lives of people, too. These stewardship and craft activities, along with songs, feasts, and celebrations, were intimately tied to the phenology of native plants, animals, and their habitats.

Table 1. Preliminary ecological and cultural assessment of plant species at six sites on the Mayacamas Mountains Sanctuary; FS=Ferguson Springs, PF=Pine Flat, RR=Rob Roy Flat, HT=Horse Trough Springs, LS=Little Sulphur Creek, SF=Schoolhouse Flat.

	Mayacamas Sanctuary site					
	FS	PF	RR	HT	LS	SF
Native vegetation cover (%)	17	50	17	39	76	31
Non-native vegetation cover (%)	83	50	83	61	24	69
Invasive vegetation cover (%)	23	26	16	3	9	32
Number of species (total)	62	65	37	46	57	36
Native species[a] (%)	29	51	35	61	74	28
Useful species[a] (%)	74	65	59	74	75	67
Edible species[a] (%)	53	42	54	63	53	56
Medicinal species[a] (%)	45	32	24	50	40	33
Area (acres)	10	3	2	1.5	1	0.3

[a]Plant species categories overlap; therefore, percents sum to over 100% within sites.

ACR PHOTO

Figure 1. "Bad-boy salad," featuring eight non-native species gathered from Ferguson Springs at ACR's Mayacamas Mountains Sanctuary.

Ecology of traditional knowledge

Observations and traditional beliefs such as those described above raise several interesting but unanswered questions. Did the ecological benefits of such practices exceed the ecological costs? Can these sorts of interactions with plants and habitats help us to restore and sustain biodiversity? Can such relationships soothe our sense of alienation from the natural world? Ecologists, historians, eco-psychologists, and others will probably be grappling with these complex questions for many years to come.

As a restoration ecologist, my imagination has been captured by folk phenology, wild tending, and TEK. These traditions suggest the possibilities of a deeper sense of participation and belonging through active partnership with biodiversity. We can employ intimate tending practices to help promote modern biological conservation. We can develop cultural activities to attract

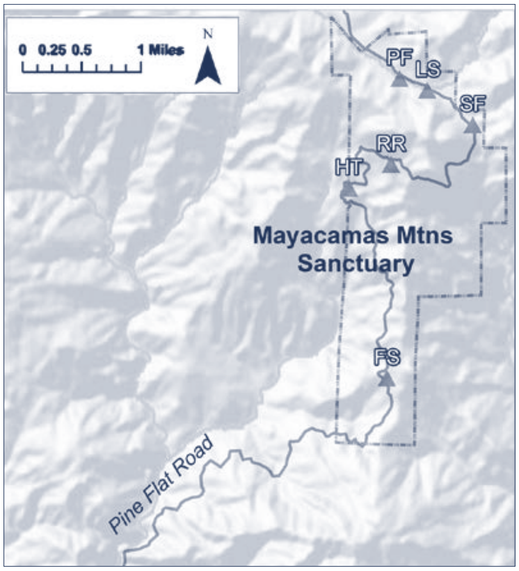

Figure 2. Audubon Canyon Ranch's Mayacamas Mountains Sanctuary (preserve border = dashed line) in northern Sonoma County, northeast of Healdsburg, and the locations of several ecological and cultural assessment sites (filled triangles): Ferguson Springs (FS), Pine Flat (PF), Rob Roy Flat (RR), Horse Trough Springs (HT), Little Sulphur Creek (LS), and Schoolhouse Flat (SF).

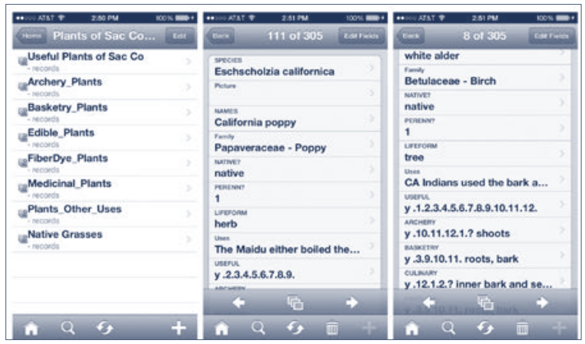

Figure 3. Prototype iPhone Guide to Seasonal Uses of Plants of Sacramento County.

stewardship volunteers who help restore and sustain habitat on the Mayacamas Mountains Sanctuary (MMS). We are learning some of what we need to know by harvesting, sowing, growing, and using seeds and plants in the garden at ACR's Modini Stewardship Center (MSC), in Healdsburg.

As noted in Ecclesiastes and echoed by both Pete Seeger and The Byrds, "There is a season and a time to every purpose under heaven." It seems that seasonal folklore, or practical folk phenology, may help us, as stewards of biodiversity, learn when to plant or sow, gather seed, and so on, for conservation.

Building a culture of stewardship

My journey into folk phenology and folk management of wild plants and habitats began about 20 years ago, long after I became an active restoration ecologist. The conservation areas where I had worked in California, the Washington, DC region, and north Florida, all needed many more hands actively engaged each season in stewardship activities such as seed collecting, sowing, invasive plant removal, planting, and weeding. Money and paid manpower for habitat stewardship, though, was (and still is) very limited. As a naturalist/educator, I was aware that guided walks to interpret human uses of wild plants, or to engage in foraging adventures, were always popular, and I suspected that these interests might serve to attract a pool of volunteers willing to help with stewardship. Together with a colleague, I used these insights to found the Restoration Trust (RT), a collaborative nonprofit organization dedicated to the long-term stewardship of mitigation sites through community engagement and education (www.therestorationtrustonline.org).

While with the RT, Susan Maxwell and I developed a number of projects that combined restoration ecology with cultural uses of some of the plants. In this mode, restoration of a creek bank on the Modini Mayacamas Preserves (MMP) might involve the removal of nonnative Himalayan blackberry *(Rubus armeniacus)* from the bank, which would then be used to make baskets. That activity would typically be coupled with the replanting of native sedges and willows. The new plants could be tended to provide materials for future basketry projects, providing a focus for further efforts to remove and replace blackberry and other non-native plants with native species. Similarly, we might remove non-native fiddle dock *(Rumex pulcher)* and curly dock *(Rumex crispus)* while planting an area to restore native grass cover, and then we might cook a delicious, dock curry.

A few projects during my first year with ACR (2013) show the strong potential for cultural approaches to stewardship. For example, "stewardship salad" programs at MMP, promoted as wild salad experiences, were organized to remove milk-thistle—at the time when this large invasive annual is most edible but is still too young to produce seed. During the stewardship work, we found seven other non-native species to add to the salad, including three species that had not yet been recorded on the preserve. We also talked about restoration ecology and the possibilities for combining other cultural experiences with invasive plant removal, restoration plantings, and the collection and sowing of native seeds. The conversations continued during salad preparation and dinner. During and after, several participants said they would happily pay for future "stewardship and craft" experiences.

As part of the "stewardship salad" series, I also prepared a slide show and another wild salad (with elderberry vinaigrette) for the ACR Board of Directors. They learned about invasive plant issues at MMP and enjoyed the taste of a wild, "Bad Boy Salad," featuring milk thistle and seven other non-native species from Ferguson Springs on the preserve (Figure 1 and 2). Both talk and salad were "consumed" with interest and enthusiasm.

Information tools

During the spring of 2013, I mapped the 13 most problematic invasive plants on the preserve. In early summer I recorded plant cover in six areas with serious infestations of invasive plants, and tabulated the species in each area as native or non-native and also by human uses. These data documented extensive non-native vegetation cover, with a modest but considerable portion represented by invasive, non-native pest plants (Table 1). The data also showed impressively extensive cover by useful species. This small data set shows some of the potential to develop cultural activities designed to help restore native species and control invasives in sites infested with non-native plants.

If we're going to reestablish reasonable native plant diversity and cover in areas like these, we will need to learn when and how to collect the seeds, treat them to break dormancies, sow or plant them, and grow them too. Some ecologists are now suggesting that we will soon need to determine better ways to help habitats thrive, and even how to help them relocate in the face of the rapidly changing climate. For all of this, we will need to engage a lot of people in active, seasonal stewardship—based on phenology and ecology in the wild and in the nursery as well. Such efforts will involve complex, inter-weaving of seasonal information on plants and habitats—and will require people with broad ecological, ethical, and cultural awareness and skills.

1. Achillea millefolium
2. Aegilops triuncialis
3. Aira caryophyllea
4. Anagallis arvensis
5. Anthemis cotula
6. Aster subulatus var. ligulatus
7. Avena barbata
8. Avena fatua
9. Baccharis pilularis var. consanguinea
10. Baccharis salicifolia
11. Briza minor
12. Brodiaea coronaria
13. Bromus carinatus var. carinatus
14. Bromus diandrus
15. Bromus hordeaceous
16. Bromus madritensis ssp. rubens
17. Bromus tectorum
18. Carex praegracilis
19. Centaurea solstitialis
20. Centaurium muehlenbergii
21. Cirsium vulgare
22. Convolvulus arvensis
23. Conyza canadensis
24. Cynodon dactylon
25. Cyperus eragrostis
26. Cyperus niger
27. Daucus carota
28. Eleocharis macrostachya
29. Eleocharis pachycarpa
30. Elymus glaucus
31. Epilobium brachycarpum
32. Epilobium ciliatum ssp. ciliatum
33. Eriogonum fasculatum
34. Eriophyllum confertiflorum
35. Erodium botrys
36. Erodium cicutarium
37. Eschscholzia californica
38. Geranium dissectum
39. Hemizonia fitchii
40. Heterotheca grandiflora
41. Hirschfieldia incana
42. Holcus lanatus
43. Holocarpha virgata ssp. virgata
44. Hordeum brachyantherum
45. Hordeum marinum
46. Hordeum murinum
47. Juncus acuminatus
48. Juncus balticus
49. Juncus bufonius
50. Juncus effusus var. pacificus
51. Kickxia elatine
52. Lactuca serriola
53. Leersia oryzoides

Cyperus eragrostis(Cype era)

Abbrev	Cype era
Species	Cyperus eragrostis
Names	tall flatsedge
Family	Cyperaceae - Sedge
Perennial	1
LifeForm	Herb
Native	1
Habitat	vernal pools, streambanks, ditches
Range	CA-FP; OR; also temp SAm
ROIND	FACW
Hydrophyte	1
Useful	y .8.9.10.11.12.
Culinary	y .8.9.10.11.? seeds
Medicinal	
DyeFiber	
Archery	
Basketry	y .10.11.12.? stems
OtherCraft	
OtherUses	
Gardening	
Flowering	.5.6.7.8.9.10.11.
Tending	y .8.9.10.11. gather seeds; .11.12.1.2.3. sow
Notes	seeds edible. stems useable in basketry.

Distribution in 1 acre plot

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
0														
1														
2														
3						3								
4				3	3									
5			3	3	15									
6			3	3										
7		3	3	3										
8		15	15	3										
9		3	3	15									15	
10	15	3						3	3					
11	3	3						3	3	15	3	3	3	15
12														
13				15										
14				3						3	15			

Figure 4. Stewardship Information System (SIS) data from the first plot in Folsom, California, with seasonal uses and distribution of each plant species in the one-acre plot.

In support of the earlier RT projects, and to deal with the underlying complexities, I developed a prototype Stewardship Information System (SIS) in Excel, for mapping, assembling, and analyzing plant cover and distributions in one-acre study plots, by species, native status, life form (shrub, tree, grass, forb, etc.), longevity (annual, biennial, perennial), wetland indicator status, flowering season, seasonal uses, and seasonal management actions (Figure 4). I then developed the "Uses" portion of the database into field guides for iPhone and iPad (Figure 3). Later, I added prototype planning and monitoring modules to the SIS, and modules for generating educational materials to accompany stewardship activities.

Neighborhood stewardship

With volunteers at the Modini Stewardship Center (MSC), I hope to refine the prototype SIS into an online platform (akin to iNaturalist or CalFlora) that would be used to facilitate stewardship across the northern San Francisco Bay area. The SIS would be used to gather and share baseline vegetation data on stewardship sites and reference sites, and to gather and share a wealth of information on the ecology, horticulture, uses and wildlife values of the plant species at those sites. The SIS helps bring site information and species information together – so that the design of stewardship projects can reflect the complex interweaving of plants, seasons, horticulture, ecology and culture.

At MMP, we hope to use the refined SIS platform to gather baseline data on species and sites, to develop and monitor stewardship projects, and to share the data, plans, efforts, and results. We also hope to use the SIS at MSC to train and support "neighborhood stewards" who will work with schools and other volunteers to restore habitats in their neighborhoods.

Eventually we plan to offer an intensive training program for neighborhood stewards that would be comparable to current training of ACR docents and to the University of California Naturalist Certification programs. The neighborhood stewards would learn to use the SIS to implement ACR-developed, stewardship and craft activities—and to develop and share their own variations at sites throughout the region. They would also use the SIS to produce new education materials—including maps, field guides and activity details—for children and adults involved in other neighborhood stewardship projects.

The "Bad Boy Salad" and prior RT projects show that we can develop science-based stewardship projects that include craft and traditional connections with nature. An SIS platform will help us manage invasive plants and restore habitat too, and may help us nurture compatible culture and ethics as well. We have a lot of work to do.

David Self is the Resource Ecologist at ACR's Modini Mayacamas Preserves and Modini Stewardship Center in Healdsburg.

Restoration of the Giacomini Wetlands stimulates winter population growth

Shorebird Recovery in Tomales Bay

by John P. Kelly

Each winter, spectacular masses of sandpipers and other shorebirds pepper the mudflats and tidal marshes of Tomales Bay. Individuals search feverishly in all directions for invertebrate prey, and their tight aerial flocks rush like gusts of wind over all parts of the estuary. Careful attention to these activities reveals a slower, rhythmic shifting of shorebirds that parallels the ebb and flow of the tides. Such behaviors are driven by complex natural processes. Changes in tidal circulation, salinity, and weather can lead to striking changes in the numbers of shorebirds in the bay (Kelly 2001a, 2001b). However, their abundances often vary more mysteriously over time.

Individual shorebirds arriving from their northern breeding grounds generally choose to winter in Tomales Bay (or other sites) as juveniles, by mid-November of their first year. They then return each fall, to repopulate the area year after year (Kelly 2001a). Occasionally, heavy winter storms can force shorebirds out of the bay, into other regions of California, to find enough food to survive the winter and prepare for their northward migration in spring. But each fall, most of the same individuals return faithfully to the bay, where they are soon joined by varying numbers of new juveniles that decide to make Tomales Bay their winter home.

K. SMITH / VIREO

Figure 1. Dunlin and other shorebirds that winter in Tomales Bay often visit the recently restored Giacomini Wetlands.

These behaviors effectively scale the sizes of winter shorebird "populations" to the profitability of Tomales Bay as a place to find polychaete worms, amphipods, or other invertebrate prey. Specifically, winter shorebird population sizes are likely to reflect the numbers of shorebirds that can share an area and still improve their potential to survive winter and, therefore, to reproduce in the following late-spring and summer. If foraging opportunities increase or decrease, parallel changes in the size of regional populations might occur.

On 30 October, 2008, ecologists at the Point Reyes National Seashore allowed the waters of Tomales Bay to flow into more than 550 acres of previously diked pastures on the Giacomini Ranch, at the extreme southern end of the bay—after nearly six decades of isolation from tidal action (National Park Service 2010). Tidal forces reshaped the new wetlands, which happen to lie in the primary zone of estuarine circulation where saltwater currents mix with freshwater runoff from the watershed. In some areas, unvegetated tide flats began to develop. In others, pickleweed *(Salicornia virginica),* marsh jaumea *(Jaumea carnosa),* and other saltmarsh vegetation began to take hold. Gradually, undulating flocks of shorebirds arrived from elsewhere in the bay, sweeping in and out of the evolving restoration site with changes in tidal exposure (Figures 1 and 2). It was exciting to see birds using the new wetland, but whether the restoration might stimulate any actual growth of surrounding shorebird populations remained unknown.

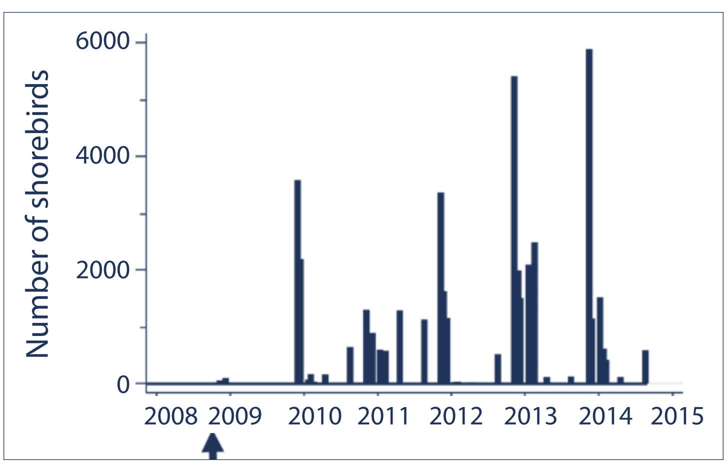

Figure 2. Number of shorebirds (all species combined) in the Giacomini Wetlands restoration site, counted annually during one fall migration count (late August), six winter counts (November–February), and one spring migration count (late April) each year. The arrow indicates the date of tidal reintroduction, on 30 October 2008.

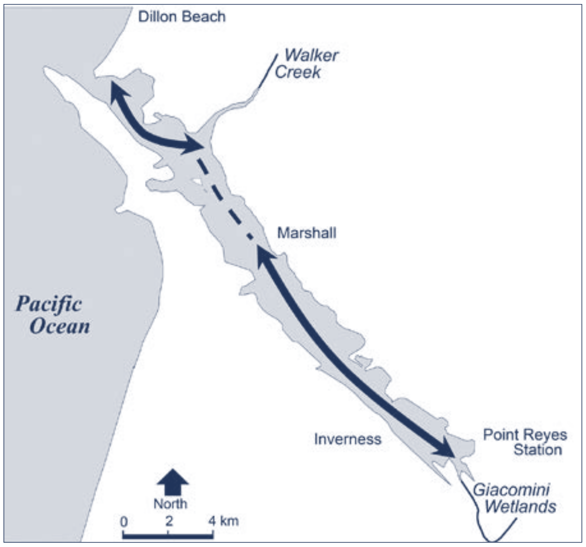

Figure 3. The net movements of wintering shorebird flocks in northern and southern Tomales Bay are oriented to the southeast during dropping tides, which expose primary feeding areas, and to the northwest during rising tides, toward high-tide roost sites in several locations around the bay. The dotted line indicates relatively little (if any) flock movement.

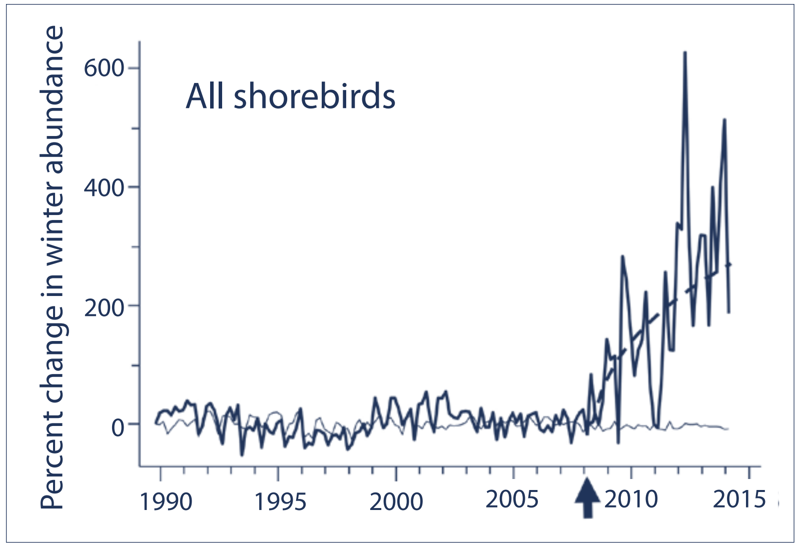

Figure 4. Percent change in overall winter shorebird abundance in southern Tomales Bay (bold line), relative to mean values prior to restoration (values are filtered to control for long-term trends and average intraseasonal differences). Time steps include only the sequence of six baywide winter surveys per year (November–February); the dashed line represents the modeled restoration effect. The arrow indicates the date of tidal reintroduction into the Giacomini Wetlands; the thin line indicates changes in northern Tomales Bay.

Monitoring population change

Habitat restoration efforts often document clearly the local responses of wildlife to newly available or enhanced habitat. However, evidence of expanded benefits to wildlife populations in the surrounding region is extremely difficult—often impossible—to find. This is because numerous other ecological processes can dominate the dynamics of populations, which generally operate over much larger areas.

In this case, however, biologists and volunteers at ACR (a key partner in the restoration effort) were hopeful that 25 years of Tomales Bay-wide shorebird monitoring would lead to important evidence of cascading regional benefits to winter shorebird populations. To look for broader responses to the restoration, we examined baywide shorebird counts gathered before and after the restoration by devoted birders working with ACR. Six years after tidal reintroduction, it became clear that the restoration effort was not just revitalizing an historic wetland—it was stimulating the growth of the surrounding winter shorebird populations in Tomales Bay.

Many years ago, we began to uncover evidence, based on baywide patterns of flock movement, that Tomales Bay supports two separate populations of wintering shorebirds, for most species, with different individuals occupying the northern and southern portions of the bay (Figure 3; Kelly 1990, 2001a, 2001b). Not surprisingly, I later found that when wintering Dunlins in northern and southern Tomales Bay were translocated to opposite ends of the bay, all of the individuals returned quickly to their more familiar wintering areas, several miles away (Kelly 2001a). Consistent with these findings, we have found that the Giacomini Wetlands restoration is benefitting, primarily, the shorebirds that winter in southern Tomales Bay (Figure 4).

Naturally dynamic landscape

We have also learned that wintering shorebird populations in the southern half of Tomales Bay are extremely sensitive to intraseasonal changes in tidal circulation, salinity, stream flow, cumulative rainfall, and extreme weather (Kelly 2001b). In contrast, populations at the northern end of the bay are, on average, nearly three times larger, more stable, and more resilient to extreme events. Consequently, the sizes of shorebird populations in southern Tomales Bay vary far more dramatically within and among years than those in northern Tomales Bay.

The differences in shorebird use between the two ends of the bay make good sense because, while estuarine foraging conditions in northern portion of the bay are moderated by daily tidal exchange with nearshore waters from the outer coast, tidal conditions in southern Tomales Bay are isolated from regular exchange with coastal waters and, in addition, subject to winter flooding events from Lagunitas Creek. During heavy winter storms, such events scour shorebird feeding areas at the southern end of the bay, devastate their marine invertebrate prey with extremely low salinities, and deposit thick layers of sediment and debris that can bury prey populations, making them unavailable to shorebirds. Such dynamics are a natural dimension of estuarine life in places like southern Tomales Bay, where tidal exchange is limited and runoff varies dramatically within and among seasons.

Although restoration of the Giacomini Wetlands has strongly enhanced winter shorebird populations in southern Tomales Bay, natural disturbance patterns that characterize this landscape may continue to result in seasonally dynamic (unstable) extremes in shorebird use (Figure 4). Nonetheless, restoration of the Giacomini Wetlands is substantially strengthening shorebird populations in southern Tomales Bay.

Winter population growth

The expanded ecological benefits of the Giacomini Wetlands restoration were revealed by consistent patterns of winter population growth among several shorebird species. Least Sandpipers, for example, responded strongly to the restoration, with regional population growth that began soon after tidal reintroduction (Figure 5). This response included early incursions into the restoration site that were apparently

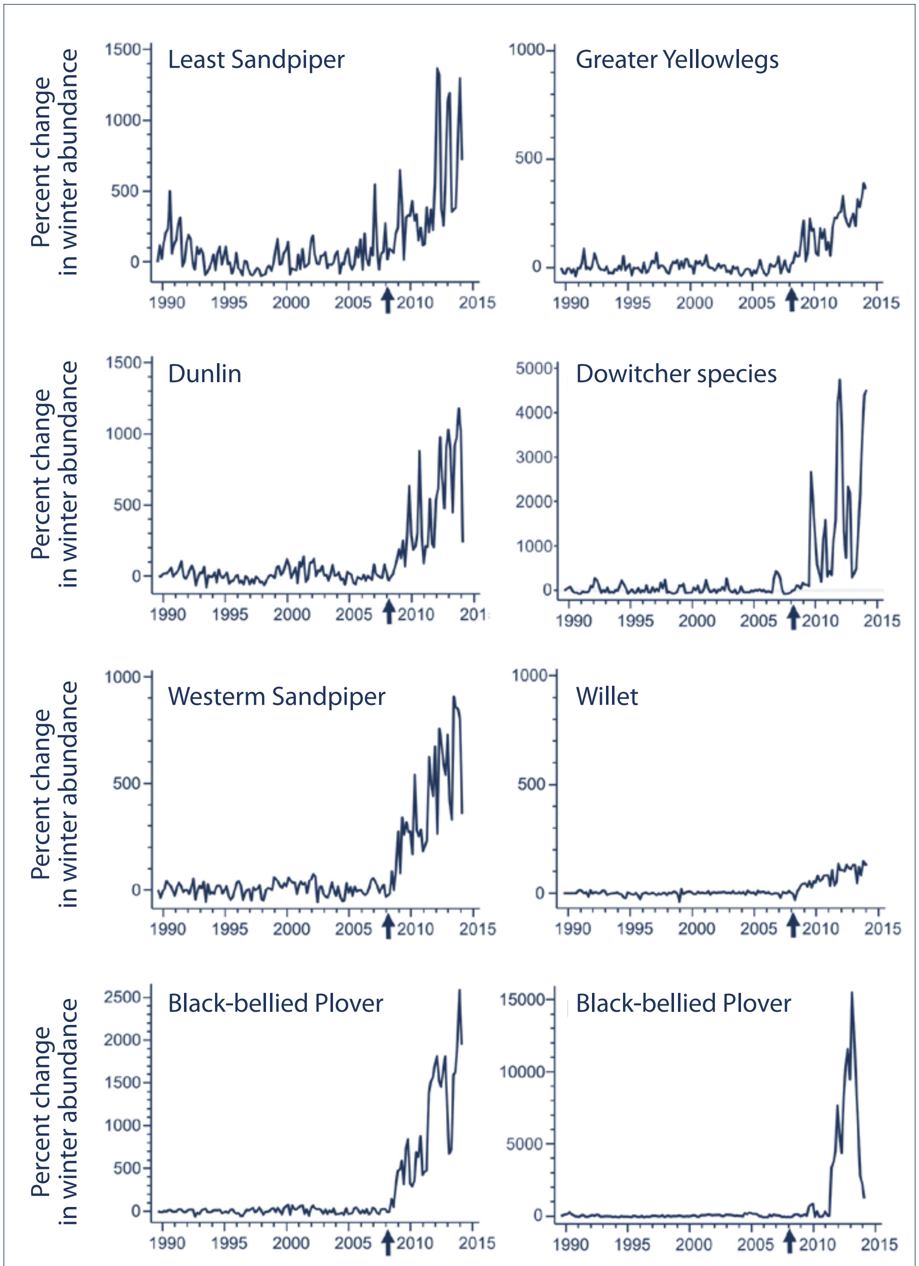

Figure 5. Percent change in winter shorebird abundances in southern Tomales Bay, relative to mean values prior to restoration (values are filtered to control for long-term trends and average intraseasonal differences). Vertical scales differ among species; time steps include only the sequence of six baywide winter surveys per year (November–February); arrows mark the date of tidal reintroduction into the Giacomini Wetlands.

facilitated by particularly profitable foraging adaptations. Unlike other small sandpipers, which generally depend on unvegetated tide flats for foraging and the quick formation of tight, evasive mobile flocks to avoid predator attacks, Leasts were able to feed among—and take refuge beneath—the relict pasture grasses before open tide flats had developed. These behavioral adaptations were especially valuable because unusually large concentrations of raptors were attracted to the developing wetlands.

Dunlin, Western Sandpiper, and Black-bellied Plover populations in southern Tomales Bay have also increased strongly in response the restoration. The continuing regional growth of these groups is apparent not only in early winter, but also in late winter, even though late-winter declines occur within each year (Figure 5). The consistent annual growth of these and other shorebird populations even in late winter suggests an important outcome: restoring tidal marshes in the heart of the estuary has allowed shorebirds to override, to some extent, the effects heavy winter storms. This outcome may have resulted from restoring the natural role of tidal marshes in reducing the impacts of storm runoff on shorebird foraging areas, or from the development of alternative areas to feed as seasonal conditions change.

Some species, such as Greater Yellowlegs have clearly benefitted from an increase in the extent of suitable habitat within the restoration site. Extensive areas of ponded water across the new marshplain are often speckled with yellowlegs wading slowly through the shallows or darting after small fishes.

Similarly, spectacular increases in the abundances of dowitcher species in southern Tomales Bay have been concentrated primarily within the restoration site. Given the generally greater predominance of Long-billed Dowitchers during winter (relative to Short-billed Dowitchers) and the extremely low numbers of dowitchers in southern Tomales Bay prior to the restoration (Table 1), the restored wetlands may have helped to establish a new wintering population of Long-billed Dowitchers. Willet and Marbled Godwit numbers, which may not vary substantially within winter, have also increased in response to the restoration.

Natural resilience

With more shorebirds in Tomales Bay, their wintering populations are likely to be more resilient, with faster recovery from habitat disturbance or annual declines. Part of this resilience is simply the result of having more wintering birds available to return each fall. Increases in the extent and diversity of available habitat—across a wider gradient of estuarine conditions—are also likely to enhance the resilience of winter shorebird populations. Expanded foraging opportunities in these new habitats may allow shorebirds to override periods of potential foraging stress without being forced to make non-migratory, mid-winter flights to other regions.

The future viability and resilience of winter shorebird populations in Tomales Bay depend on the potential for the elevations of key foraging areas—unvegetated tide flats and emergent tidal marshes—to keep pace with rising seas and increasingly heavy pulses of runoff from winter storms expected with the changing climate. By increasing the natural connectivity between estuarine and terrestrial habitats, the Giacomini Wetlands restoration has dramat-

Table 1. Mean winter shorebird abundances in southern Tomales Bay, 1989–2008, before restoration of the Giacomini Wetlands (back-transformed from loge values). Prior to restoration, shorebirds were nearly three times more abundant, on average, in northern Tomales Bay than in the southern portion of the bay. See Figures 4 and 5 for changes in winter abundance after restoration.

	Early winter (November–December)		Late winter (January–February)		Winter (November–February)	
	Mean	95% Confidence interval	Mean	95% Confidence interval	Mean	95% Confidence interval
Black-bellied Plover	22	16-32	11	7-17	10	8-13
Dowitcher species	11	6-19	4	2-6	8	5-10
Least Sandpiper	467	351-621	67	36-127	146	106-201
Western Sandpiper	245	151-400	42	21-84	116	79-171
Dunlin	742	440-1250	49	24-102	70	43-116
Greater Yellowlegs	17	14-20	4	3-5	8	7-10
Willet	80	57-113	153	119-197	73	59-92
Marbled Godwit	75	55-102	96	64-147	69	55-88
All shorebirds	2727	2206-3371	1092	851-1401	1399	1180-1658

ically improved the potential for shorebird foraging areas to shift southward—into the upper portions of the restoration site (nearly 40 percent of the area is above the current reach of tides) and even into the nearby lowlands of the Olema and Bear valleys. The improved ability of tidal wetlands to adjust and recalibrate naturally with the changing climate suggests a very positive outlook for shorebirds in Tomales Bay.

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John P. Kelly is ACR's Director of Conservation Science.

Visiting investigators

Audubon Canyon Ranch hosts graduate students and visiting scientists who rely on the undisturbed, natural conditions of our sanctuaries 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.

Harbor seal monitoring in northern Tomales Bay. Mary Ellen King, Pinniped Monitoring Program, Point Reyes National Seashore.

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 Wetlands. 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.

Monitoring Avian Populations (MAPS) banding station at Livermore Marsh. Erin Rowan, The Institute for Bird Populations, Point Reyes Station.

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, and Pepperwood Preserve.

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

In Progress:
project updates

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

Bolinas Lagoon Heron and Egret Project ◗ To evaluate effects of the 2014 abandonment of the heronry at ACR's Martin Griffin Preserve, we are closely monitoring changes in heron and egret nesting abundance and distribution in Bolinas Lagoon (see The Ardeid 2014).

Tomales Bay Shorebird Census. ◗ Since 1989, we have conducted annual shorebird censuses on Tomales Bay. Each annual census involves eight baywide counts, six in winter counts and one each in the August and April migration periods. The data are used to investigate winter population patterns, local habitat values, responses to restoration of the Giacomini Wetlands in southern Tomales Bay, and implications for shorebird conservation.

Tomales Bay Waterbird Census. ◗ Since the winter of 1989–90, teams of 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.

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. ACR's 250-page regional atlas of heronries in the San Francisco Bay Area is available online (www.egret.org/atlas) along with an updated Google-Earth program showing the locations and status of individual heronries (www.egret.org/googleearthheronries). Results are used to measure the effects of climate change, evaluate the impacts of colony-site disturbances, and track the regional status of nesting herons and egrets in the San Francisco Bay area.

Four Canyons Project. ◗ In the lower reaches of four canyons at ACR's Martin Griffin Preserve, we are controlling invasive plant species and using locally collected and propagated plant materials to restore the native vegetation.

Monitoring and Control of Non-Native Crayfish. ◗ Together with the Bouverie Stewards and Junipers, Bouverie staff is studying the distribution of non-native signal crayfish *(Pacifastucus lenisculus)* in Stuart Creek and investigating control methods to reduce the impacts of crayfish on native amphibians and other species.

Plant Species Inventory. ◗ Resident biologists maintain inventories of plant species known to occur on ACR lands, including ACR's Tomales Bay properties, Bouverie Preserve, Martin Griffin Preserve, Mayacamas Mountains Sanctuary, and Modini Ingalls Ecological Preserve. Bouverie Preserve science staff have enlisted the help of volunteers and high school students to integrate the native species inventories with the shared on-line database iNaturalist.

Annual Surveys and Removal of 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.

Monitoring and Eradication of 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 floodplains and 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 new patches introduced from other areas by high tides and currents.

Removal of *Ammophila arenaria* in Coastal Dunes. ◗ Removal of invasive dune grass *(Ammophila arenaria)* at ACR's Toms Point is helping to restore and protect native species that depend on mobile dune ecosystems.

Vernal Pool Restoration. ◗ At Bouverie Preserve, we are monitoring the federally listed endangered plant Sonoma sunshine *(Blennosperma bakeri)* that ACR restored to the Preserve's vernal pools in 2009. We also continue to monitor the California species of conservation concern, dwarf downingia *(Downingia pusilla),* and native plant populations. We continue to remove invasive plants that encroach upon vernal pools, using manual removal and rotational cattle grazing.

Yellow Starthistle at Modini Ingalls Ecological Preserve. ◗ 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 established a monitoring program and developed guidelines to reduce the spread of this invasive pest plant.

Serpentine and Rare Plant Survey at Modini Ingalls Ecological Preserve. ◗ Sherry Adams and volunteers identified and mapped unique plant assemblages associated with serpentine outcrops and completed an ACR report, with management recommendations, to help understand their status in the central Mayacamas Mountains.

Breeding Bird Assessment at Modini Ingalls Ecological Preserve. ◗ Using breeding-bird atlas and point-count methods, we are assessing the breeding status, abundance, and distribution of bird species at MIEP. This work will contribute to an understanding of regional bird use in the central Mayacamas Mountains.

Breeding Bird Assessment in the central Mayacamas Mountains. ◗ We are measuring the densities and abundances of breeding birds along Pine Flat Road, northeast of Healdsburg in northern Sonoma County. The survey route includes 16 point-count stations, extends from the bottom to the top of Pine Flat Road, and includes ACR's Mayacamas Mountains Sanctuary. Interested birders who can identify local breeding bird species by ear are encouraged to contact the Cypress Grove Research Center or visit https://sites.google.com/site/acrmms-breedingbirdsurvey/home.

Oak Woodland Restoration. ◗ With the successful completion of Project GROW (Gathering to Restore Oak Woodlands) in 2014, ACR is now partnering with the Hanna Boys Center and volunteer groups to expand its oak woodland restoration sites by planting additional native tree species such as madrone, as well as native perennial grasses at its restoration sites.

Wildlife Movement Research. ◗ ACR has partnered with the Felidae Conservation Fund's Bay Area Puma Project to record mountain lion activity at Bouverie Preserve with remote wildlife cameras since 2011.Bouverie staff are currently expanding these efforts as part of the Wildlife Observers Network Bay Area (WONBA) in partnership with other local conservation and land preservation organizations in the Sonoma Valley.

Control of Invasive Pest Plants at Bouverie Preserve. ◗ To protect and restore vernal pool, grassland, and upland habitats at Bouverie Preserve, we are mapping and removing infestations of more than 12 invasive non-native plant species.

AUDUBON CANYON RANCH

acr

conservation in action

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THE ARDEID

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

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Conservation Science
and Habitat Protection
at Audubon Canyon Ranch

AUDUBON CANYON RANCH PROTECTS NATURE THROUGH LAND PRESERVATION, ENVIRONMENTAL EDUCATION, AND CONSERVATION SCIENCE.

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BOUVERIE PRESERVE • MODINI MAYACAMAS PRESERVES

Wintering populations of shorebirds, including Black-bellied Plovers, are increasing in southern Tomales Bay.

TOM GREY

Shorebird Recovery see page 9

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