Conservation Science and
Habitat Protection at
Audubon Canyon Ranch

THE ARDEID

◗ regional disturbance

outcasts on the wing

◗ Mayacamas Sanctuary

ecosystem services

◗ Tomales Bay watershed

species of local interest

◗ Bouverie Preserve

stitching a landscape

2012

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Modeling the regional effects of disturbance at heron and egret colonies

Outcasts on the Wing

by Sarah Millus

ROBERT MILLNUS

Every year, egrets return to Picher Canyon at Audubon Canyon Ranch's Martin Griffin Preserve (MGP), on Bolinas Lagoon, to build nests and raise their young. It is something that we have come to expect. Around March, their sleek white figures begin to dot the towering redwoods, and exclamations of "The egrets are back!" are shared throughout the canyon.

The herons and egrets that return to this canyon are carrying on a tradition that has lasted for decades. The first record of Great Egrets *(Ardea alba)* on Bolinas Lagoon dates to 1929 (Pratt 1983, Western Birds 14:169-181), when they began reappearing in this area after they were apparently extirpated by plume hunters in the 1880s. Egrets that forage in the lagoon are generally known to nest in Picher Canyon, so it seems likely that egrets foraging on the lagoon in the 1920s were breeding in Picher Canyon. However, herons and egrets do not always return to the same nesting sites or wetland feeding areas year after year.

Heron and egret breeding colonies are dynamic, as the number of nesting pairs fluctuates across years. We have observed both dramatic and gradual changes in heron and egret numbers at MGP. More than 50 Great Blue Herons *(Ardea herodias)* nested in the canyon when monitoring first began in 1967, but their numbers decreased gradually over several decades, and the species was absent in the canyon during the last couple of years. The underlying reasons for such changes are generally a mystery.

We know from other studies that shifts in the breeding distributions of herons and egrets are influenced by several factors (Kushlan and Hafner 2000, Heron Conservation, Academic Press; Kelly et al. 2008, Wetlands 28:257-275). Food resources affect the number of young that parents can raise, and if food resources are poor near a particular colony, herons may not return to breed at that site in subsequent years. Disturbance is another factor that can affect the dynamics and distribution of heronries. Disturbances to heronries range from harassment by juvenile Bald Eagles *(Haliaeetus leucocephalus)* to the removal of nesting trees to changes in nearby human activity.

Herons and egrets are able to withstand some disturbance, but levels that exceed their thresholds of tolerance may lead them to abandon a colony. When disturbed, they will readily move to nearby breeding colonies, or they may leave the wetland area altogether, which could lead to a decline in the number of nesting herons and egrets in the surrounding landscape. Understanding the effects of disturbance at one colony is therefore important for understanding the

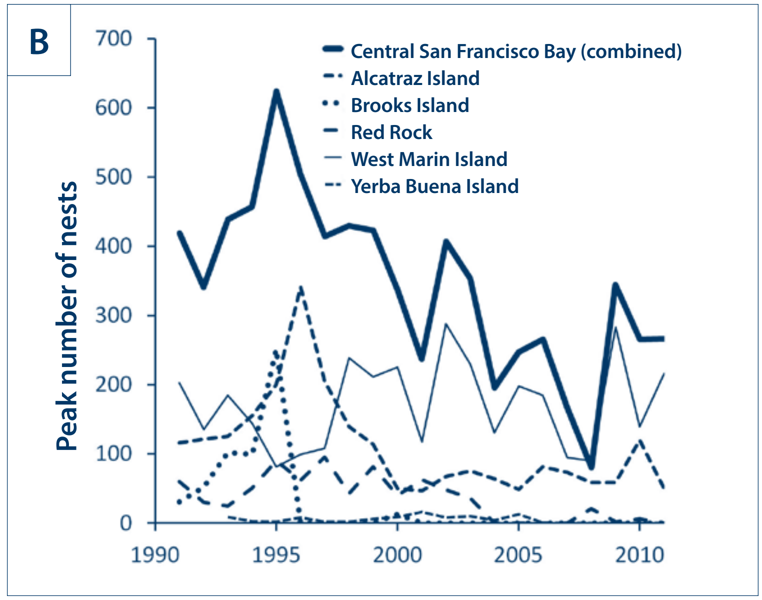

Figure 1. (A) Map of Black-crowned Night-Heron nesting colonies in Central San Francisco Bay. **(B)** Annual Black-crowned Night-Heron nesting abundance in Central San Francisco Bay 1991–2011. After the abandonment of Brooks Island in 1996, overall nesting abundance of night-herons increased on Alcatraz Island but decreased in the Central San Francisco Bay area.

dynamic nature of heron and egret abundance and distribution.

I am currently working with ACR's John Kelly and Emiko Condeso to investigate the effects of colony-size fluctuations on region-wide abundance of herons and egrets. The analysis is based on over 20 years of monitoring data and the work of numerous volunteer field observers who contribute to ACR's Heron and Egret Project, an ongoing effort to track the nesting activities of herons and egrets in the northern San Francisco Bay area. We currently monitor over 150 colony sites, and the resulting data are used to measure changes in the size and location of colonies as well as reproductive success of individual nests.

The responses of herons and egrets to nesting disturbance are illustrated by several examples in our study area. One striking example concerns Black-crowned Night-Herons *(Nycticorax nycticorax)* in Central San Francisco Bay. Brooks Island, located just off Richmond's Marina Bay (Figures 1A and 2), has historically been an important breeding colony site for night-herons. Prior to the breeding season in 1996, a non-native red fox *(Vulpes vulpes)* made its way onto Brooks Island, and that year the colony was abandoned. That same year, overall nest abundance in the Central Bay decreased, although the number of breeding Black-crowned Night-Herons increased on Alcatraz Island (Figure 1B). Presumably, some of the individuals from Brooks Island moved to Alcatraz, but it was not enough to account for the number that failed to return to Brooks Island and too many birds were missing to suspect that they had all died. During the next four years, the number of nests on Alcatraz continued to decrease (for unknown reasons). These decreases had an impact on the total abundance of breeding Black-crowned Night-Herons in Central San Francisco Bay. It is also interesting to note that Black-crowned Night-Herons have not yet returned to Brooks Island (although 13 pairs did nest there in 2000), suggesting that the presence of the fox in early 1996 has had a lasting impact on the total night-heron abundance in Central San Francisco Bay.

Unmasking disturbance effects

The observed effect of disturbance at a particular colony site on the region-wide abundance of nesting herons and egrets leads to several potentially important questions. How does disturbance at one colony affect the nesting abundance of a wetland subregion such as Tomales Bay, the Napa Marsh, or the Laguna de Santa Rosa? How long does it take for a wetland subregion to recover from a disturbance at a particular site? How do multiple impacts at one or more colonies within a subregion affect the recovery? We are addressing these questions using a time series analysis of annual heron and egret nesting abundances in ten wetland subregions of the northern San Francisco Bay area. Time series analysis allows us to evaluate changes in heron and egret nest numbers in each subregion, using data collected as part of the Heron and Egret Project.

Just as everything in nature is connected in space, elements are also connected in time. Nesting abundance naturally varies over time, and this variation is not random. The number of breeding pairs in a particular wetland area in one year is closely related to the number of breeding pairs in previous years. Therefore, the number of nesting birds that return to nest each year cannot be treated as a purely random collection of independent abundances but, rather, represents a string of interrelated data points. The first step of time series analysis involves using mathematical models to describe this natural variation. These initial models form the basis of our analysis and remove the ”noise” that results from natural, expected changes in nesting abundance. This variation needs to be accounted for in our models; otherwise it can obscure the effect of a disturbance event. Once normal variation is accounted for, we can then examine the effect of a disturbance.

Figure 2. If disturbed, nesting Black-crowned Night-Herons may not choose to nest at other colony sites in the surrounding wetland landscape but, instead, may move to a distant subregion (Figure 1).

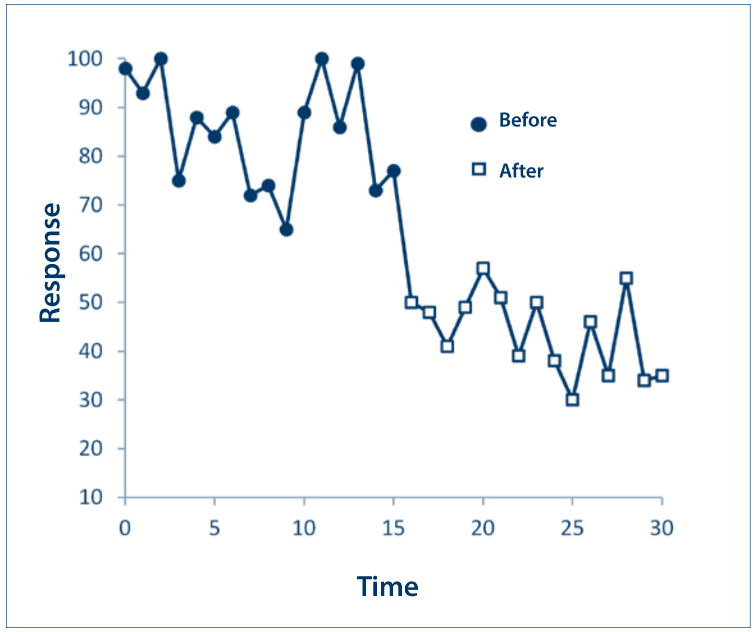

Figure 3. Time series plot of simulated data with a disturbance at observation time 15. Time series analysis controls for the natural variation in a dataset. Adding an intervention component to the model allows us to examine differences in the height and slope of the time series before and after a disturbance.

Significant changes in the number of herons or egrets within a wetland area, such as those caused by a colony-site disturbance, are considered to be an "interruption" of the natural variation in the data. The next step in our analysis is to add a component to the model that describes the effect of the colony-site disturbance. This changes the analysis from a simple time series to an "interrupted time series" analysis. If a colony-site disturbance impacts the number of birds nesting in the surrounding wetland area, the post-disturbance data will have a different level or slope than the pre-disturbance data (Figure 3).

Two parameters estimated from the interrupted time series model allow us to evaluate the level of a disturbance event and its duration. One parameter is ω (omega), which estimates the difference between the data series before and after the disturbance event. It is a measure of how many nests were lost in a given wetland area due to a particular disturbance. The other parameter, δ (delta), can be interpreted as the rate of recovery after a disturbance. The δ value is large if nest abundances after the disturbance made a slow recovery back towards its level prior to the disturbance. Therefore, the δ parameter can be used to make inferences about the resilience of a given wetland area, i.e., its ability to absorb colony-site disturbance and maintain overall nesting abundance within the surrounding area.

Once these parameters are estimated from the time series model, the real fun can begin. We can use these parameters to make predictions about how colony-site disturbances might affect overall nest abundance in any particular wetland area. We will be able to simulate disturbances of different magnitudes, as well as model the effects of repeated disturbances. Also, because the sizes of wetland areas vary across our study area, we will be able to determine the extent to which recovery rates are related to the size of the wetland area. For example, the wetland subregion of Drakes Estero is much smaller than the wetland subregion that encompasses Suisun Bay. Disturbance events of similar magnitude may have dramatically different effects on heron and egret abundance in these two areas. Birds that abandon a colony in Drakes Estero have limited opportunities to establish a new colony site or immigrate to another existing colony in the Estero, because nesting and foraging habitat is more limited in this area. Suisun Bay provides ample habitat for both nesting and foraging, and birds that leave a colony in this wetland region may more easily establish a colony within the same area.

When a heronry is threatened by increased human activity or proposed development, the apparent availability of other possible nesting sites in the area is often claimed as a compensating consideration. Unfortunately, we currently have no scientifically substantiated way to determine the effects of colony disturbance on the surrounding area. These time series models will provide planners and decision-makers with a valuable tool for predicting the extent to which impacts to particular heronries are likely to affect the number of herons and egrets that nest and feed in the surrounding wetland landscape.

Sarah Millus is ACR's Helen Pratt Field Biologist and specializes on studies of herons and egrets.

Mayacamas Mountains Sanctuary, ACR's newest preserve

Through the Lens of Ecosystem Services

by Sherry Adams

Visitors to Audubon Canyon Ranch's newest preserve can enjoy views of Mount Saint Helena, see spring wildflowers, and hear the clear call of a Mountain Quail. But there are many other ways in which the Mayacamas Mountains Sanctuary (MMS) is valuable to humans, ones that are less often recognized.

Ecological systems provide numerous benefits of particular value to humans. These include "goods" such as raw materials to make the paper this is printed on, the clothes you are wearing, or the materials that went into building your home. Ecosystem benefits to humans also include "services" such as the important function of soil and roots in storing and cleaning water that can be used later for agricultural and residential use, or the way plants consume CO_2, produce O_2, and facilitate other processes needed to regulate the atmospheric gases that make this planet habitable for human life.

Using the term "goods and services," borrowed from economics, in the same sentence as "ecosystem" may seem incongruous. If you are in the habit of thinking of the value of natural areas as inherent and not in need of justification or quantification, this may seem to be a debasing or inappropriate way to think about natural systems. But regardless of the terminology we use, natural systems play a life-supporting role for humans. By explicitly recognizing this value, we can potentially broaden the support for protecting these areas. As one scientist put it, "we don't protect what we don't value" (Reichert 1997).

The field of ecological economics includes a variety of key terms and ideas related to ecosystem services. The flow of energy and the cycling of nutrients and water are *ecosystem processes. Ecosystem function* is the capacity of natural processes and components to provide goods and services that satisfy human needs (De Groot 2002). You may have to pay for some *ecosystem goods and services,* such as the cost of a piece of lumber from a managed forest, a fillet of a fish from an ocean, an apple from an orchard, or sewage fees for the assimilation of waste, which eventually gets deposited in terrestrial or aquatic systems. Major categories of ecosystem goods and services are listed in Box 1.

The price humans pay for a particular ecosystem good or service may not reflect its complete cost, and many ecosystem services that are not traded in the marketplace are therefore unpriced. One study found that, if tabulated, the value of global ecosystem services would exceed the global Gross National Product (Costanza et al. 1997), which suggests that the unpriced components far exceed what we pay. This is particularly true of ecosystems outside of managed agricultural and silvicultural systems.

Many of the goods and services provided by wildlands are not explicitly quantified or even recognized, yet all humans rely on these goods and services. According to the Ecological Society of America, about a third of the human food stream relies on the thousands of species of wild pollinators (Ecosystem Services Fact Sheet: www.esa.org/ecoservices). One study in Texas estimated the pest-control value of a species of bat that eats some crop pests at close to $1 million (Cleveland et al. 2006).

Consider the complex but frequently overlooked processes involved in soil production. Organic matter produced by photosynthesizing organisms is mixed and cycled by decomposers, moved by animals and erosive forces, and enhanced by mineral nutrients that are added and made available by a combination of weathering and biological processes. River floodplains, long known as particularly productive farmland, depend on soil carried from other places in the watershed, where soil formation is occurring. Soils are then combined with organic matter produced elsewhere in the river or other aquatic systems to which it is connected. Next time you are enjoying the agricultural products of the fertile Russian River floodplain, consider the role that MMS and other natural areas high in the watershed play in building that fertility.

The donation you are willing to make to visit a nature preserve and enjoy the emotional and educational benefits of the visit is an example of one sort of valuation of an ecosystem service: the price that people

Box 1: Categories of ecosystem goods and services (Farber et al. 2006)

- Gas regulation
- Climate regulation
- Disturbance regulation
- Biological regulation
- Water regulation
- Soil retention
- Waste regulation
- Nutrient regulation
- Water supply
- Food
- Raw materials
- Genetic resources
- Medicinal resources
- Ornamental resources
- Recreation
- Aesthetics
- Science and education
- Spiritual and historic

SHERRY ADAMS

Figure 1. Mount Saint Helena, shown here snow-capped in February of 2011, is visible from ACR's Mayacamas Mountains Sanctuary (MMS). The opportunity to enjoy vistas such as this one is an example of the recreational services that MMS provides.

are willing to pay to ensure the protection of places like the Mayacamas Mountains Sanctuary. In some cases, expanding valuation to include the unpriced goods and services provided by intact ecosystems can help to protect them.

The value of an intact ecosystem

When the city of New York was comparing the cost of protecting the Catskills and Delaware watersheds, which provide its drinking water, with the cost of a new water treatment system, a specific dollar amount could be calculated. In that case, the billions of dollars needed to protect the watersheds that provide clean water was less than the price of building a water treatment system. This is an indirect method of assigning value, by calculating the cost of replacement—if replacements are available. While the intact watersheds that provide the drinking water may be priceless, we know what it would cost to artificially purify the water: it would cost more than the current program, in place since the late 1990s, which buys property from willing landowners and implements a wide variety of clean-water programs such as septic system upgrades, erosion reduction, and updated agricultural practices.

The ecosystem services provided by wildlands such as MMS can be put in two broad categories: regulating services and cultural services. Regulating services include (1) carbon sequestration, (2) climate and water regulation, (3) protection from natural hazards such as floods, (4) water and air purification, and (5) disease and pest regulation (Fischlin et al. 2007). Cultural services provided by MMS include educational, aesthetic, and recreational opportunities that are protected and made available by ACR (Figure 1).

The services provided by natural processes may depend on extensive and interconnected landscapes. For example, let's consider how a nature preserve affects something as basic as the availability of drinking water in the surrounding region. When a drop of rainwater lands on MMS, it filters through the soil, slowed by the roots and microorganisms and, if not taken up by organisms, makes its way to the Russian River via Big Sulphur Creek, Maacama Creek, or Sausal Creek. The grasslands, forests, and shrublands of the watershed itself are a significant storage system, releasing the water to the Russian River much more slowly than runoff over impervious surfaces. Some of the creeks are perennial, meaning they are still holding and delivering water to the Russian River in late summer. The creeks and river and their surrounding saturated zones are also important water storage. The Russian River is the primary source for residential and agricultural water across Sonoma County and into Marin County, transported by extensive pipelines.

The next time you are watching birds, enjoying wildflowers, or taking in the view at MMS or another natural area, consider also the role that natural, undeveloped lands play in sustaining human life. Improving the way we understand, catalog, and articulate the many ways that ecosystems benefit humans has the potential to expand appreciation and support for protecting natural areas. While conservation is expensive, it's a great bargain.

References cited

Cleveland, C.J., M. Betke, P. Federico, J. D. Frank, T. G. Hallam, J. Horn, J. D. López, Jr., G. F. McCracken, R. A. Medellín, A. Moreno-Valdez, C. G. Sansone, J. K. Westbrook, and T. H. Kunz. 2006. Economic value of the pest control service provided by Brazilian free-tailed bats in south-central Texas. Frontiers in Ecology and the Environment 4:238–243

Costanza, R., R. d'Arge, R. de Groot, R., S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. V. O'Neill, J. Paruelo, R. G. Raskin, P. Sutton, and M. van den Belt. 1997. The value of the world's ecosystem services and natural capital. Nature 38:253-260.

De Groot, R. S., M. A. Wilson, R. M. J. Boumans. 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41:393-408.

Farber, S., R. Costanza, D. L. Childers, J. Erickson, K. Gross, M. Grove, C. S. Hopkinson, J. Kahn, S. Pincetl, A. Troy, P. Warren, and M. Wilson. 2006 Linking ecology and economics for ecosystem management: a services-based approach with illustrations from LTER sites. BioScience 56:117-129.

Fischlin, A., G. F. Midgley, J. T. Price, R. Leemans, B. Gopal, C. Turley, M. D. A. Rounsevell, O. P. Dube, J. Tarazona, and A. A. Velichko. 2007. Ecosystems, their properties, goods, and services. Pages 211-272, in M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (eds.), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge.

Reichert, J. S. 1997. Perspectives on nature's services. Pages xviii to xx in: G. C. Daily (ed.), Nature's Services, Societal Dependence on Natural Ecosystems. Island Press, Washington, DC.

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Fine-tuning conservation in the Tomales Bay watershed

Species of Local Interest

by John P. Kelly

Sometimes, the graceful movement of a heron is enough to rekindle one's commitment to conservation. If you have ever been revived by this, or by a similar experience, then you know that it can stir up related thoughts or ideas that further strengthen the effect. For example, you might notice a heron moving slowly through the shallows, strategically tilting its head to track the movement of its prey. Such a peek into the life of an iconic wetland predator can certainly strengthen how one values the natural world, but the encounter would likely to be more deeply inspiring if you knew that, locally, the species is a "High Priority" conservation concern because of its declining presence in the surrounding watershed. Such is the status of Great Blue Heron *(Ardea herodias)* in Tomales Bay.

Our relationship with nature often depends on what we know. Is there any doubt that your personal response to a delicate damselfly landing quietly on a nearby perch would be enhanced if you knew that the insect was a San Francisco fork-tail damselfly *(Ischnura gemina)*—a local conservation "Priority" that is sensitive to urban sprawl and persists only in scattered locations from southern Sonoma County to Santa Cruz? Like personal connections with nature, focused biological assessments can deepen our collective drive to protect or manage local species.

Similarly, understanding the local threats imposed by invasive ecological pests, such as the European green crab *(Carcinus maenas)* or perennial pepperweed *(Lepidium latifolium)* in Tomales Bay, seems crucial in motivating efforts to control their potentially devastating impacts on native species—because such efforts often depend on "a stitch in time."

The escalating global conservation crisis continues to challenge our optimism, but undercurrents of positive, local action are building. Such local activity is part of a solid global process, as Paul Hawkins demonstrated several years ago when he discovered that hundreds of thousands of locally organized efforts to heal the earth have grown into the biggest movement in the history of the planet (Hawken 2007). I recently collaborated with Tom Gardali, of PRBO Conservation Science, and Jules Evens, of Avocet Research Associates (Evens 2005, 2008), on a series of biological assessments intended to inspire local action.

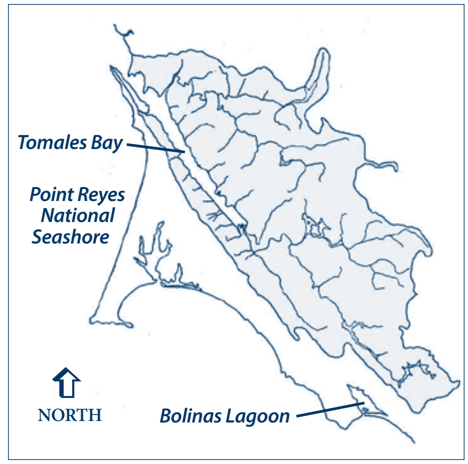


Figure 1. The Tomales Bay watershed (shaded) drains 255 square miles of western Marin County, California.

Table 1. Criteria used for scoring Species of Local Interest. Each criterion is scored as "1" (yes) or "0" (no or unknown).

Species of Local Concern

1. ***Major Ecological Importance (E).*** The species is likely to have a major role in protecting a local ecosystem or another Species of Local Concern.
2. ***Locally Rare or Declining (R).*** The species resides seasonally or year-round in the watershed and is rare or undergoing a non-cyclic decline in abundance.
3. ***Iconic (I).*** The species is charismatic to local cultural perspectives and its status is likely to draw broad attention or concern.
4. ***Socio-economic Significance (S).*** The species is native and has demonstrable positive influence on human culture or livelihoods or special importance to indigenous cultures.
5. ***Habitat Significance and Endemism (H).*** The species' preferred habitat in the watershed is an important component of its endemic distribution, or its habitat association important to the biological diversity of the watershed.

Local Ecological Pest Species

1. ***Presence in the Watershed (P).*** Some ecological pests are listed without confirmation of their presence because they can be difficult to detect and may invade from surrounding areas.
2. ***Status (L).*** The species is identified by a reference agency or organization as a high priority for eradication or management.
3. ***Major Ecological Threat (T).*** The species is likely to have a major role in degrading a local ecosystem or reducing the abundance of a Species of Local Concern.
4. ***Locally Abundant or Increasing (A).*** The species is common or increasing rapidly in abundance.
5. ***Socio-economic Significance (S).*** The species has demonstrable negative influence on human culture or livelihoods.

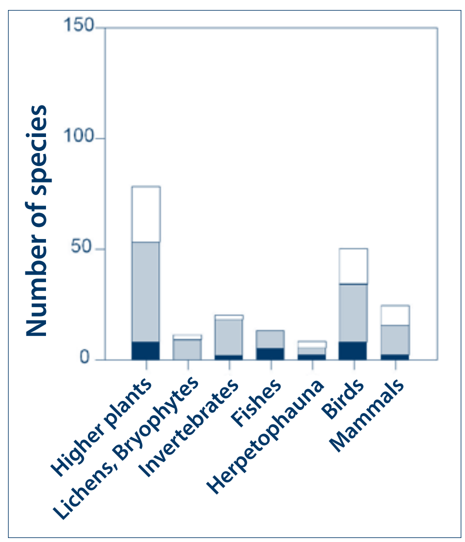


Figure 3. General taxonomic distribution of Tomales Bay Species of Local Concern. Stacked bars indicate High Priority species (black bars), Priority species (gray bars), and unprioritized species (white bars).

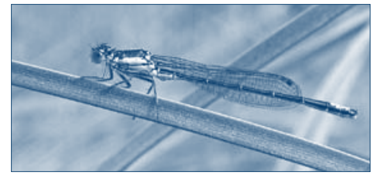
We developed a working list of Species of Local Interest (SOLI) for the Tomales Bay watershed (Gardali et al. 2011; Figure 1). The project is a key Action Item of a Watershed Stewardship Plan developed by the Tomales Bay Watershed Council (www.tomalesbaywatershed.org). The Council is a collaboration of agencies and local organizations that work to implement the Plan.

A local tool for local conservation

The SOLI list provides a means for prioritizing and promoting local projects to protect and restore native species and habitat areas. We expect that the list will be used by scientists, policy makers, environmental planners, land managers, conservation organizations, and restoration practitioners. SOLI is a dynamic list, subject to ongoing revision as we improve our understanding of local species in the Tomales Bay Watershed.

We nominated species for the SOLI list based on our knowledge of the watershed and input from a diverse group of other local experts. Species may qualify for inclusion on the list only if they occur in the watershed in a primary role as year-round, breeding-season, or winter-season residents. Transient species are excluded. We also excluded cultivated species and pet species that are not feral in the watershed. Ecological pest species not currently present—or not confirmed to be present—are included if they pose a significant ecological threat to the watershed.

Because the complex processes that sustain life operate at multiple scales, effective conservation action must consider the appropriate local, regional, national, or international context of each issue. We therefore included local species that are state or federally threatened or endangered, or are considered worthy of special conservation status in one or more of 47 lists developed by key scientific organizations and government agencies.

GOBY-SEA SAVE FOUNDATION
DAMSEFLY-RON LEVALLEY

Figure 2. Species of Local Concern in Tomales Bay watershed include the tidewater goby (left) and San Francisco forktail damselfly.

The SOLI list is divided into two parts, each with set of scoring criteria (Table 1). The final scores reflect an attempt to represent the best available information, based on published papers, unpublished reports, and expert review. However, because of the frequent lack of precise data, many scores rely substantially on expert opinion. We identified 205 species as Species of Local Concern and 165 as Local Ecological Pest Species.

We classified the relative importance of each nominated species, based on the sum of scores across the scoring criteria. "High Priority" species are those with summed scores of 4 or 5; "Priority" species are those with scores for 2 or 3 of the criteria. In the full report and associated database (Gardali et al. 2011), we also compiled information on the seasonal status, habitat associations (based on general classifications used by Calflora: www.calflora.org), technical references, and knowledgeable people to contact regarding each species.

Local patterns

Of 205 Species of Local Concern (e.g., Figure 2), we identified 120 Priority species and 28 High Priority species (Table 2). Higher plants (modern plants with vascular conducting tissue) and birds were predominant among Priority and High Priority Species of Local Concern (Figure 3). However, the results may underestimate the importance of other taxonomic groups, because ecological information needed to qualify as Priority or High Priority species is often not available. Priority and High Priority Species of Local Concern are most commonly associated with wetlands (Figure 4). Among the Priority and High Priority wetland species, 32% are birds, 18% are higher plants, 18% are fishes, and 15% are invertebrates.

Of 166 Local Ecological Pest Species, we identified 48 Priority species and 57 High Priority species (Table 3). A relatively large number of invertebrates were included as Local Ecological Pests but did not qualify as Priority pests because many of them require additional information to determine their status (Figure 5). Priority and High Priority

continued on page 9

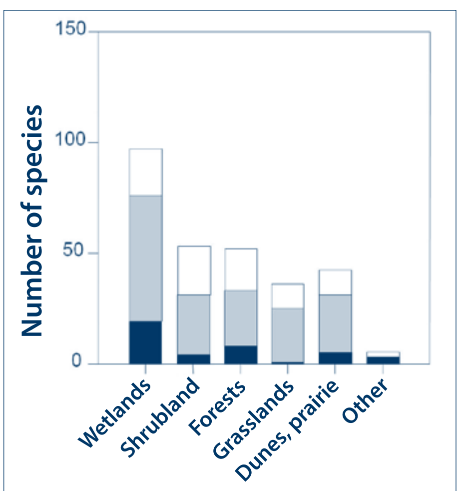


Figure 4. Distribution among general habitat types of Species of Local Concern in the Tomales Bay watershed. Stacked bars indicate High Priority species (black bars), Priority species (gray bars), and unprioritized species (white bars).

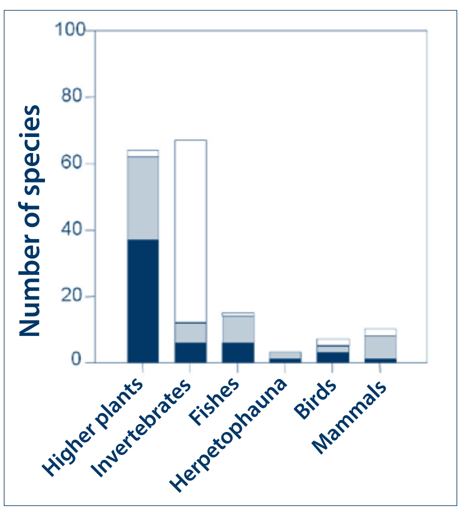


Figure 5. General taxonomic distribution of Local Ecological Pest Species in the Tomales Bay watershed. Stacked bars indicate High Priority species (black bars), Priority species (gray bars), and unprioritized species (white bars).

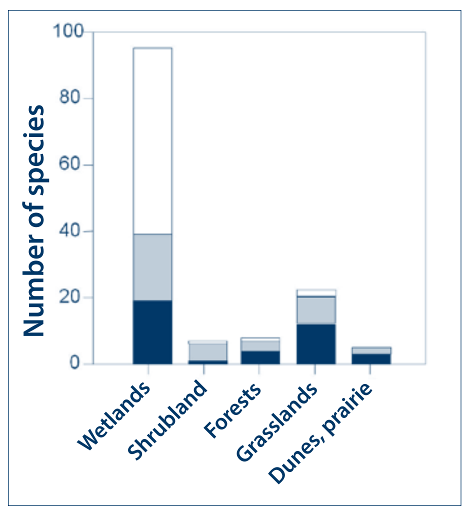


Figure 6. Distribution among general habitat types of Local Ecological Pest Species in the Tomales Bay watershed. Stacked bars indicate High Priority species (black bars), Priority species (gray bars), and unprioritized species (white bars).

Table 2. Criterion scores for High Priority and Priority Species of Local Concern in the Tomales Bay watershed (see Table 1 for criteria codes).

Common name	Scientific name	E R I S H
High Priority species		
Western snowy plover	*Charadrius alexandrinus nivosus*	1 1 1 1 1
Pacific herring	*Clupea pallasii*	1 1 1 1 1
California black rail	*Laterallus jamaicensis coturniculus*	1 1 1 1 1
Coho salmon	*Oncorhynchus kisutch*	1 1 1 1 1
Steelhead	*Oncorhynchus mykiss irideus*	1 1 1 1 1
Coast redwood	*Sequoia sempervirens*	1 1 1 1 1
Northern spotted owl	*Strix occidentalis caurina*	1 1 1 1 1
California freshwater shrimp	*Syncaris pacifica*	1 1 1 1 1
Pacific pond turtle	*Actinemys marmorata (marmorata)*	1 1 1 0 1
Point Reyes mountain beaver	*Aplodontia rufa phaea*	1 1 1 0 1
Great blue heron	*Ardea herodias*	1 1 1 0 1
Brant	*Branta bernicla*	1 0 1 1 1
Point Reyes ceanothus	*Ceanothus gloriosus gloriosis*	1 1 1 0 1
Mt. Tamalpais thistle	*Cirsium hydrophlum* var. *Vaseyi*	1 1 1 0 1
Point Reyes bird's beak	*Cordylanthus (Chloropyron) maritimus palustris*	1 1 1 0 1
Yellow larkspur	*Delphinium luteum*	1 1 1 0 1
Yellow warbler	*Dendroica petechia brewsteri*	1 1 1 0 1
Tidewater goby	*Eucyclogobius newberryi*	1 1 1 0 1
Tidestrom's lupine	*Lupinus tidestromii*	1 1 1 0 1
Chinook salmon	*Oncorhynchus tshawytscha*	1 1 1 1 0
Osprey	*Pandion haliaetus*	1 0 1 1 1
Harbor seal	*Phoca vitulina*	1 0 1 1 1
Mountain lion	Puma concolor	1 1 1 0 1
Mt. Tamalpais live-oak	*Quercus parvula* var. *tamalpaisensis*	1 1 1 0 1
California clapper rail	*Rallus longirostris obsoletus*	1 1 1 0 1
California red-legged frog	*Rana draytonii*	1 1 1 0 1
Myrtle's silverspot butterfly	*Speyeria zerene myrtleae*	1 1 1 0 1
Pacific eelgrass	*Zostera marina (latifolia)*	1 0 1 1 1
Priority species		
Pink sand verbena	*Abronia umbellata breviflora*	1 1 0 0 1
Green sturgeon	*Acipenser medirostris*	1 1 0 1 0
Tricolored blackbird	*Agelaius tricolor*	1 1 0 0 1
Point Reyes (Calif.) bentgrass	*Agrostis densiflora (puntareyensis?)*	0 1 1 0 1
Grasshopper sparrow	*Ammodramus savannarum*	1 1 0 0 1
Golden eagle	*Aquila chrysaetos*	1 1 1 0 0
Mt. Tamalpais manzanita	*Arctostaphylos hookeri montana*	0 1 1 0 1
Bolinas manzanita	*Arctostaphylos virgata*	1 0 1 0 1
Great egret	*Ardea alba*	1 0 1 0 1
Burrowing owl	*Athene cunicularia*	1 1 1 0 0
Point Reyes blennosperma	*Blennosperma nanum* var. *robustum*	1 0 1 0 1
Coastal bryoria	*Bryoria pseudocapillaris*	1 1 0 0 1
Tomales isopod	*Caecidotea tomalensis*	0 1 1 0 1
Bay ghost shrimp	*Callianassa californiensis*	1 1 0 1 0
Dungeness crab	*Cancer magister*	1 0 1 1 0
Humboldt Bay owl's clover	*Castilleja ambigua humboldtensis*	1 1 0 0 1
Northern harrier	*Circus cyaneus*	1 1 1 0 0
Francisco thistle	*Cirsium andrewsii*	1 1 0 0 1
Townsend's big-eared bat	*Corynorhinus townsendii*	1 1 0 0 1
Yellow rail	*Coturnicops noveboracensis*	0 1 1 0 1
Baker's larkspur	*Delphinium bakeri*	0 1 1 0 1
California giant salamander	*Dicamptodon ensatus*	1 0 1 0 1
"Tomales Dunes" smooth scouring rush	*Equisetum laevigatum (? aff. Ferrisii)*	1 0 1 0 1
Gray whale	*Eschrichtius robustus*	1 0 1 1 0
Common yellowthroat	*Geothlypis trichas sinuosa*	1 1 0 0 1
Foliose "spotted owl" lichen	*Heterodermia leucomelos*	1 1 0 0 1
Coast iris	*Iris longipetala*	0 1 1 0 1
San Francisco forktail damselfly	*Ischnura gemina*	1 1 0 0 1
Tomales toach	*Lavinia symmetricus* ssp. 2	1 1 0 0 1
Point Reyes meadowfoam	*Limnanthus douglasii ssp sulphurea*	0 1 1 0 1
River otter	*Lutra canadensis Sonora*	1 0 1 0 1
Bat ray	*Myliobatis californica*	1 0 1 0 1
Black-crowned night-heron	*Nycticorax nycticorax*	1 0 1 0 1
Olympia oyster	*Ostrea lurida*	0 1 1 0 1
California halibut	*Paralichthys californicus*	1 0 0 1 1
"Marin" chestnut-backed chickadee	*Parus rufescens neglectus*	0 1 1 0 1
California brown pelican	*Pelecanus occidentalis californicus*	1 1 1 0 0
Double-crested cormorant	*Phalacrocorax auritus*	1 0 1 0 1
"Point Reyes" blue butterfly	*Plebejus icarioides parapheres*	0 1 1 0 1
Purple martin	*Progne subis*	0 1 1 0 1
Pacific littleneck	*Protothaca staminea*	1 1 0 1 0
Foothill yellow-legged frog	*Rana boylii*	1 1 0 0 1
Mt. Tamalpais jewelflower	*Streptanthus glandulosus pulchellus*	0 1 1 0 1

Common name	Scientific name	E R I S H
American badger	*Taxidea taxus*	1 1 1 0 0
Woven-spore lichen	*Texosporium sancti-jacobi*	1 1 0 0 1
Eulachon (smelt)	*Thaleichthys pacificus*	1 1 0 1 0
Blue mud shrimp	*Upogebia pugettensis*	1 1 0 1 0
Intertidal lichen	*Verrucaria tavaresiae*	1 1 0 0 1
California sea lion	*Zalophus californianus*	1 0 1 1 0
Point Reyes jumping mouse	*Zapus trinotatus orarius*	1 1 0 0 1
Sharp-shinned hawk	*Accipter striatus*	0 1 1 0 0
Chamise	*Adenostoma fasciculatum*	1 0 0 0 1
California false-indigo	*Amorpha californica* var. *napensis*	0 1 0 0 1
Bent-flower fiddleneck	*Amsinckia lunaris*	0 1 0 0 1
Pallid bat	*Antrozous pallidus*	0 1 0 0 1
Short-eared owl	*Asio flammeus*	1 1 0 0 0
Top smelt	*Atherinopsis affinis*	1 0 0 1 0
Jacksmelt	*Atherinopsis californiensis*	1 0 0 1 0
Ringtail	*Bassariscus astutus*	0 1 0 0 1
Short coastal fructose lichen	*Bryoria subcana*	0 1 0 0 1
Coastal bluff morning glory	*Calystegia purpurata saxicola*	1 0 0 0 1
Swamp harebell	*Campanula californica*	1 1 0 0 0
Lyngbyei's sedge	*Carex lyngbyei*	1 0 0 0 1
Mt. Vision ceanothus	*Ceanothus gloriosus porrectus*	0 1 1 0 0
Tall glory-bush	*Ceanothus gloriosus* var. *exaltus*	1 0 0 0 1
Spineflower	*Chorizanthe cuspidata villosa*	1 1 0 0 0
Raiche's red-ribbons	*Clarkia concinna* spp. *Raichei*	0 1 0 0 1
Globose dune beetle	*Coelus globosus*	0 1 0 0 1
Monarch butterfly	*Danaus plexippus*	0 1 1 0 0
Western leatherwood	*Dirca occidentalis*	0 1 0 0 1
Snowy egret	*Egretta thula*	0 0 1 0 1
White-tailed kite	*Elanus leucurus*	1 0 1 0 0
Northern anchovy	*Engraulidae mordax mordax*	1 0 1 0 0
Koch's cord moss	*Entosthodon kochii*	0 1 0 0 1
California horned lark	*Eremophilia alpestris actia*	0 1 0 0 1
Tiburon buckwheat	*Eriogonum luteolum* var. *caninum*	0 1 0 0 1
Merlin	*Falco columbarius*	1 0 1 0 0
American peregrine falcon	*Falco peregrine anatum*	1 0 1 0 0
American kestrel	*Falco sparverius*	0 1 1 0 0
Dune gilia	*Gilia capitata chamissonis*	0 1 0 0 1
San Francisco gumplant	*Grindelia hirsutula maritime*	0 1 0 0 1
Bald eagle	*Haliaetus leucocephalus*	1 0 1 0 0
Black albalone	*Haliotis cracherodii*	0 1 1 0 0
Pinto abalone	*Haliotis kamtschatkana*	0 1 1 0 0
Marin western flax	*Hesperolinon congestum*	1 1 0 0 1
Santa Cruz tarplant	*Holocarpha marcradenia*	0 1 0 0 1
Thin-lobed horkelia	*Horkelia tenuiloba*	0 1 0 0 1
Marin elfin butterfly	*Incisalia mossii*	0 1 0 0 1
Pacific lamprey	*Lampetra tridentata*	1 1 0 0 0
Loggerhead shrike	*Lanius ludovicianus*	0 1 0 0 1
Hoary bat	*Lasiurus cinereus*	1 1 0 0 0
Rose linanthus	*Leptosiphon rosaceus*	0 1 0 0 1
Tamalpais lessingia	*Lessingia micradenia* var. *micradenia*	0 0 1 0 1
Bumblebee scarab beetle	*Lichnanthe ursina*	0 1 0 0 1
Harlequin lotus	*Lotus formosissimus*	0 1 0 0 1
Short-tailed weasel	*Mustela erminea steatori*	1 0 0 0 1
Marin navarretia	*Navarretia rosulata*	0 1 0 0 1
American white pelican	*Pelecanus erythrorhynchos*	0 1 1 0 0
Brandt's cormorant	*Phalacrocorax penicillatus*	1 1 0 0 0
Devil's matchsticks	*Philoporus acicularis*	1 1 0 0 1
North coast semaphore grass	*Pleuropogon hooverianus*	0 1 0 0 1
Lobb's water buttercup	*Ranunculus lobbii*	0 1 0 0 1
Washington clam	*Saxidomus nuttalli*	1 0 0 1 0
Marin checkerbloom	*Sidalcea hickmanii* spp. *Viridis*	0 1 0 0 1
Purple checkerbloom	*Sidalcea malviflora* ssp. *purpurea*	0 1 0 0 1
Black-chinned sparrow	*Spizella breweri*	0 1 0 0 1
Tiburon jewelflower	*Streptanthus batrachopus*	0 1 0 0 1
Dune tansy	*Tanacetum camphoratum* (syn: *bipinnatum*)	0 1 0 0 1
Lichenized fungus	*Teloschistes flavicans*	0 1 0 0 1
Thamnolia lichen	*Thamnolia vermicularis*	0 1 0 0 1
Calif. red-sided garter snake	*Thamnophis sirtalis infernalis*	0 1 1 0 0
Leopard shark	*Triakis semifasciata*	1 0 1 0 0
Coastal trichodon	*Trichodon cylindricus*	0 1 0 0 1
Showy indian clover	*Trifolium amoenum*	0 1 0 0 1
Creeping seagrass	*Triglochin concinna*	1 0 0 0 1
San Francisco owl's clover	*Triphysaria (Orthocarpus) floribunda*	0 1 1 0 0
Yellow cetrarioid lichen	*Tuckermannopsis canadensis*	1 0 0 0 1
"Nuttall's" white-crowned sparrow	*Zonotrichia leucophrys nuttalli*	0 1 0 0 1

Table 3. Criterion scores for High Priority and Priority Ecological Pest Species in the Tomales Bay watershed (see Table 1 for criteria codes).

Common name	Scientific name	P L T A S
High Priority species		
Barbed goatgrass	*Aegilops triuncialis*	1 1 1 1 1
European beach grass	*Ammophila arenaria*	1 1 1 1 1
European green crab	*Carcinus maenas*	1 1 1 1 1
Giant plumeless thistle	*Carduus acanthoides*	1 1 1 1 1
Distaff thistle	*Carthamus lanatus*	1 1 1 1 1
Napa thistle (Tocalote)	*Centaurea melitensis*	1 1 1 1 1
Purple star thistle	*Centaurea calcitrapa*	1 1 1 1 1
Yellow star thistle	*Centaurea solstitialis*	1 1 1 1 1
Canada thistle	*Cirsium arvense*	1 1 1 1 1
Bull thistle	*Cirsium vulgare*	1 1 1 1 1
Scotch broom	*Cytisus scoparius*	1 1 1 1 1
Cape ivy	*Delairea odorata*	1 1 1 1 1
Colonial sea squirt	*Didemnum sp. A*	1 1 1 1 1
Invasive colonial tunicate	*Didemnum vexillum*	1 1 1 1 1
Veldt grass	*Ehrharta erecta*	1 1 1 1 1
Eucalyptus	*Eucalyptus globulous*	1 1 1 1 1
Mosquito fish	*Gambusia holbrooki*	1 1 1 1 1
French broom	*Genista monspessulana*	1 1 1 1 1
Velvet grass	*Holcus lanatus*	1 1 1 1 1
Wild turkey	*Meleagris gallopavo*	1 1 1 1 1
Harding grass	*Phalaris aquatica*	1 1 1 1 1
American bullfrog	*Rana catesbeiana*	1 1 1 1 1
Barred owl	*Strix varia*	1 1 1 1 1
Medusahead	*Taeniatherum caput- medusae*	1 1 1 1 1
Common gorse	*Ulex europaeus*	1 1 1 1 1
Black acacia	*Acacia melanoxylon*	1 1 1 1 0
Silver wattle	*Acacia dealbata*	1 1 1 1 0
Fertile capeweed	*Arctotheca calendula*	1 1 1 1 0
Common reed	*Arundo donax*	0 1 1 1 1
Star sea squirt	*Botryllus schlosseri*	1 0 1 1 1
Coyote	*Canis latrans*	1 1 0 1 1
Iceplant	*Carpobrotus edulis (& C. chilensis)*	1 1 1 1 0
Iberian starthistle	*Centaurea iberica*	0 1 1 1 1
Poison hemlock	*Conium maculatum*	1 1 1 1 0
Pampas grass	*Cortadera jubata*	1 1 1 1 0
Orange cotoneaster	*Cotoneaster francheti*	1 1 1 1 0
Silverleaf cotoneaster	*Cotoneaster pannosus*	1 1 1 1 0
Portuguese broom	*Cytisus striatus*	1 1 1 1 0
Oblong spurge	*Euphorbia oblongata*	1 1 1 1 0
Tall fescue	*Festuca arundinacea*	1 1 1 1 0
Mosquito fish	*Gambusia affinis*	1 0 1 1 1
Klamathweed	*Hypericum perforatum*	1 1 1 1 0
Rough cat's-ear	*Hypochaeris radicata*	1 1 1 1 0
Channel catfish	*Ictalurus punctatus*	1 1 1 0 1
Perennial pepperweed	*Lepidium latifolium*	1 1 1 1 0
Large-mouth bass	*Micropterus salmoides*	1 1 1 0 1
Striped bass	*Morone (Roccus) saxatilis*	1 0 1 1 1
Kikuyugrass	*Pennisetum clandestinum*	1 1 1 1 0
Sudden oak death	*Phytophthora ramorum*	1 1 1 0 1
Black crappie	*Pomoxis nigromaculatus*	1 1 1 0 1
Black locust	*Robinia pseudoacacia*	1 1 1 1 0
Dense cordgrass	*Spartina densiflora*	1 1 1 1 0
Spanish broom	*Spartium junceum*	1 1 1 1 0
Eurasian collared dove	*Streptopelia decaocto*	1 1 1 1 0
Atlantic oyster drill	*Urosalpinx cinerea*	1 1 1 0 1
Japanese littleneck clam	*Venerupis philippinarum*	1 1 0 1 1
Spiny cocklebur	*Xanthium spinosum*	1 1 1 0 1
Priority species		
Yellowfin goby	*Acanthogobius flavimanus*	1 1 1 0 0
Eupatorium	*Ageratina adenophora*	1 1 1 0 0
Tree of heaven	*Ailanthus altissima*	1 1 1 0 0
Barred tiger salamander	*Ambystoma tigrinum mavortium*	0 1 1 1 0
Australian saltbush	*Atriplex semibaccata*	1 0 1 1 0
Wild mustard	*Brassica nigra*	1 1 0 1 0
Cheat grass	*Bromus tectorum*	1 1 0 1 0
Goldfish	*Carassius aurartus auratus*	1 1 1 0 0
Italian thistle	*Carduus pynocephalus*	1 1 1 0 0
White pine blister rust	*Cronartium ribicola*	0 1 1 0 1
Common carp	*Cyprinus carpio*	1 1 1 0 0
Fallow deer	*Dama dama*	1 1 1 0 0
Stinkweed	*Dittrichia graveolens*	1 1 0 1 0
Perennial veldtgrass	*Ehrharta calycina*	0 1 1 1 0
Chinese mitten crab	*Eriocheir sinensis*	0 1 1 0 1
Caper spurge	*Euphorbia lathyris*	1 0 1 1 0
Domestic cat	*Felis silvestris*	1 0 1 1 0
Fennel	*Foeniculum vulgare*	1 1 1 0 0
English holly	*Ilex aquifolium*	1 1 1 0 0
Argentine ant	*Iridomyrmex humilis*	1 1 1 0 0
Bluegill	*Lepomis macrochirus*	1 1 1 0 0
Green sunfish	*Lepomis cyanellis*	1 1 1 0 0
Redear sunfish	*Lepomis microlophus*	1 1 1 0 0
Ox-eye daisy	*Leucanthemum vulgare*	1 1 0 1 0
Pennyroyal	*Mentha pelegium*	1 1 1 0 0
Golden shiner	*Notemigonus crysoleucas*	1 1 1 0 0
White crappie	*Pomoxis annularis*	1 1 1 0 0
Himalaya blackberry	*Rubus discolor*	1 1 0 1 0
Eastern fox squirrel	*Sciurus niger*	1 0 1 1 0
Red-eared slider	*Trachemys scripta elegans*	1 1 1 0 0
Periwinkle	*Vinca major*	1 1 1 0 0
Red fox	*Vulpes fuscipes*	1 1 1 0 0
Dwarf (Japanese) eelgrass	*Zostera japonica*	0 1 1 0 1
Toxic dinoflagellate	*Alexandrium minutum*	0 1 0 0 1
Rattlesnake grass	*Briza maxima*	1 0 1 0 0
Pampgrass	*Cortadera selloana*	0 1 1 0 0
Orchard grass	*Dactylis glomerata*	1 0 1 0 0
Ribbed mussel	*Geukensia demissa*	1 0 1 0 0
Licorice plant	*Helichrysum petiolare*	1 1 0 0 0
Perennial pea	*Lathyrus latifolius*	1 1 0 0 0
House mouse	*Mus musculus*	1 0 1 0 0
Soft-shell clam	*Myaarenaria*	0 0 1 0 1
English (house) sparrow	*Passer domesticus*	1 0 1 0 0
Norway rat	*Rattus norvegicus*	1 0 1 0 0
Black rat	*Rattus rattus*	1 0 1 0 0
Smooth cordgrass	*Spartina alterniflora*	0 1 1 0 0
European starling	*Sternus vulgaris*	1 0 1 0 0
Leathery sea squirt	*Styela clava*	1 1 0 0 0

Local Ecological Pest Species are most common in wetland and grassland habitats (Figure 6). Among the Priority and High Priority pests associated with wetlands, 35% are fishes, 30% are higher plants, and 25% are invertebrates. Higher plants account for 90% of the Priority and High Priority pest species in grasslands.

Plants and animals are responding to changes in climate in a variety of ways, including changes in seasonal reproductive timing, geographic distributions, and population sizes. The consequences of climate change, for most species, are currently too uncertain to support their use as listing criteria. Ultimately, it is essential to consider species' climate sensitivities in determining conservation priorities. Because wetlands are especially vulnerable to changes in hydrology and climate-induced sea level rise—and the highest percentage of SOLI are wetland species—we identified wetlands as a priority for research and conservation.

A list can be more than just a list if it enhances our understanding of a place. We hope the SOLI list will help to facilitate local conservation action in the Tomales Bay watershed.

References cited

Gardali, T., J. P. Kelly, J. Evens. 2011. Tomales Bay Watershed Species of Local Interest: native and non-native species of conservation or management concern. A Report of the Tomales Bay Watershed Council. [online: www.egret.org/node/869]

Evens, J. G. 2005. Introduction to California Birdlife. University of California Press, Berkeley, CA.

Evens, J. G. 2008. Natural History of the Point Reyes Peninsula. University of California Press, Berkeley, CA.

Hawken, P. 2007. Blessed Unrest. Viking Press, New York. [www.blessedunrest.com]

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Stitching the seam of a frayed landscape

Bouverie Preserve

by Theo Michaels and Jennifer Potts

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Figure 1. *Calendula arvensis* (Asteraceae) is native to central and southern Europe. This annual forb is characterized by a bright yellow to orange inflorescence that is less than 4 cm wide. Its glandular leaves give off a pungent scent.

If you have ever worked with fabric, you know the potential of the edges to fray. One can notch the fabric to contain the fray or fold over the fabric and stitch a seam, but the greater the number of edges, the greater the chance of the threads to unravel and, as a result, more work is required to keep the fabric intact. We live in a world with increasing edges. Housing developments and roads, vineyards and power line corridors, all create edges between ecosystems. This leads to fragmentation of habitat and an expansion of transitional areas. This development influences patterns of solar radiation, soil richness and erosion, wind damage, hydrological cycles, and water pollution. As a result, edges become pathways for invasion by non-native plant species, and the integrity of the landscape, like fabric, begins to fray (Booth et al. 2003).

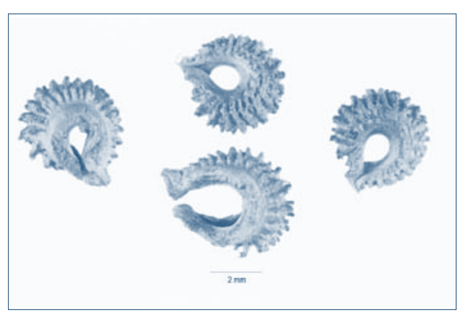
The Bouverie Preserve of Audubon Canyon Ranch is a landscape of significance in part because of its protected ecosystems surrounded by environmentally compromised edges. To the west of the Preserve runs Highway 12. Thousands of vehicles travel on this road each day, carrying with them the potential to introduce and spread weed seeds. Directly adjacent to the Preserve is Sonoma Valley Regional Park, where invasive plant species including *Hypericum canariense* (Klamath weed) and *Centaurea solstitialis* (yellow star thistle) persist. And stitched throughout the valley to the north and south lie the vineyards. Vineyard growers often plant the space between their rows with a cover crop to create a monoculture mat of herbaceous flowers in order to curb the growth of European annual grasses before they have a chance to establish. One of their most prominent cover crops is *Calendula arvensis* (commonly called field marigold, hereafter referred to as Calendula; Figure 1). In January soon after the first rains, while most of Sonoma Valley lays dormant and gray, this brilliant orange flower begins to dot the muted rows between the grapes. However, at the same time, Calendula also begins to sprout across the natural grasslands and oak savannas of Bouverie Preserve. Indeed, Calendula has become an invasive plant species of serious concern. Like many invasive plants, Calendula thrives in disturbed soils and alters the conditions needed to sustain native vegetation. Thus, a "solution" for weeds from the viewpoint of a vineyard manager has become a weed itself in conservation areas.

Plant biology on the fray

The name "Calendula" stems from the Latin root "kalendae," a word that has been interpreted as "monthly." Thus, this name suggests that Calendula is present throughout the year. Although this is a bit of an overstatement, the flowering cycle of Calendula does extend over many months and across several seasons. Indeed, observations at Bouverie Preserve have tracked the presence of Calendula from January well into June. Part of Calendula's flowering success is due to its ability to produce three different fruit types: rostrate, cymbiform, and annular (Figure 2). Each type has unique behaviors, related to its reproductive development, that extend the germination, flowering, and fruiting periods of the plant. Rostrate and cymbiform fruits are large, heavy, and adapted to long-range dispersal (De Clavijo 2005). Annular fruits, on the other hand, are smaller in size and weight and are adapted to short-range dispersal. In addition, Calendula is "self-compatible," meaning that it is capable of self-fertilizing without the presence of pollinators. With this arsenal of adaptations, Calendula is well-suited for establishment and expansion in unpredictable and disturbed habitats. In 2011, Calendula was placed on the California Invasive Plant Council's Watchlist, a list of species that do not yet qualify for their statewide inventory of invasive pests but are reported as spreading in California wildlands. At Bouverie Preserve, however, Calendula is clearly defining itself as a high-priority invasive plant.

First unravelings

Just as important as a plant's biology is knowing a plant's history. The history of a plant informs a restoration ecologist how a plant may have found its way to a given area, its longevity at the site, and its rate of spread.



STEVE HURST, USDA-NRCS PLANTS DATABASE

Figure 2. Annular achenes, one of three types of dry, one-seeded fruits produced by *Calendula arvensis*.

Although it appeared elsewhere in Sonoma Valley, Calendula was not observed at Bouverie Preserve until 1997, when it was noted by ACR Land Steward John Martin. Prior to that year David Bouverie regularly disked the vineyard rows. Martin recalls that the equipment used to disk the fields was borrowed from neighboring vineyards. He further notes that it was after the disking was discontinued that Calendula appeared. Although scientific evidence is lacking, we think that the regular disking—the turning of soil—may have kept Calendula from emerging. However, since its first appearance a the Preserve, Calendula has come to dominate key areas of the Preserve, including a large portion of the old vineyard (currently, the Project GROW oak woodland restoration site), areas along the driveways leading into the Preserve, grasslands surrounding Gilman Hall, and the perimeter of the Quarry pond, which is home to *Downingia pusilla,* a California vernal pool plant species of concern. These first unravelings of the previous plant assemblages tell us that Calendula may travel on equipment and that keeping a close watch for new populations in areas where vehicles or equipment have been used, such as roads and trails, is important in controlling its spread.

THEO MICHAELS

Figure 3. *Calendula arvensis* study site at Bouverie Preserve. White flags in the photo mark the corners of 1-m^2 study plots

Stitching the seam

While only about one percent of all non-native plants entering the United States become invasive, those that do invade have devastating and lasting environmental impacts (Booth et al. 2003). Invasive plants not only take an environmental toll, they also consume time and resources in our attempts to control them. Therefore, it is important to have a multi-level management plan to check invasion. The first step is to identify and map infestations. The second step involves containment, removal and, if possible, eradication. If eradication or containment strategies are not possible, resource ecologists must assess long-term objectives and determine whether an invasive species is worth targeting at the expense of addressing other management goals.

Currently, we are working to control and remove 22 invasive plant species at Bouverie Preserve. The time and resources needed to address each invasive plant priority must be weighed and balanced with the priorities of other invasive plants and also with our commitments to ongoing restoration projects. When Sherry Adams stepped into the Bouverie Preserve Habitat Protection and Restoration Project Leader position in 2007, she identified Calendula as a management concern. Using GPS and a geographic information system (GIS), Adams mapped all of the known Calendula locations on the Preserve, noting details including the extent and percent cover of each infestation. This information was then documented in the Preserve's weed database. Once the patches were identified, Adams began hand-pulling plants at various targeted locations and logging her work, including the time required and number of plants removed. Documentation such as this is vital to weed control, in that it helps resource ecologists to assess the effectiveness of treatments and to see if the techniques need to be adjusted or altered. In the case of Adams' work, hand-pulling proved to be effective in containing large infestations and removing outlier patches. Nonetheless, the technique was time-consuming and labor-intensive and, therefore, challenged other high-priority invasive plant removal needs.

To search for a more effective Calendula removal strategy, we collaborated with ACR Vegetation Specialist Matthew Danielczyk on a simple, informal investigation of potential removal techniques. The techniques included hand-pulling, mowing, and tarping, as well as a limited, one-time treatment with post-emergent and pre-emergent herbicides (each classified as safe for unrestricted use and applied using certified procedures and standard protocols). As a policy, ACR avoids the use of herbicides, using them only when the control of invasive pest plants is critical and other control methods prove ineffective. We applied each of the removal techniques and a no-action "control" treatment, separately, to six 1-m^2 plots, totaling 42 plots in all (Figure 3). We laid out the tarping at the beginning of the study, in March 2010. Mowing was performed monthly, and hand-pulling every two weeks, through the month of June. We monitored the plots monthly from March through June, using California Native Plant Society cover classifications to capture the percent cover of Calendula on each plot. In addition, we photographed each plot during the first week of each month to show the cover changes. Monthly monitoring ended in June, with the seasonal senescence of Calendula. When Calendula began its growing season in January 2011, plots were measured a final time, ten months after the initial monitoring began.

The limited scope of the monitoring effort prevented us from precisely distinguishing the effects of management from other underlying influences among plots or years, but the observations efficiently provided us with some useful information. Ten months after the previously infested plots were hand-pulled or treated with pre-emergent herbicide, Calendula cover declined to less than 1%. We also observed that the Calendula cover was actually greater in plots subjected to mowing and post-emergent herbicide than in untreated plots. Tarping had mixed results, possibly related to tarp damage but, where the tarp remained intact, Calendula germination was low. However, we do not know the size or longevity of the underlying seed bank.

By practical necessity, Preserve management activities must be adaptive, often based on informal observations of nature rather than expensive scientific investigations. By monitoring a set of several small plots, measuring the extent of infestation on the Preserve, and tracking labor hours, we generated useful information that helps us to assess and adjust our approach to managing Calendula. For example, we are very careful to watch newly disturbed areas for Calendula infestations because the monitored plots suggested that bare soil might invite infestation. We are also careful to address mowed areas around the Preserve, as this practice seems to stimulate Calendula populations.

To track Calendula management, we designed a Google Earth map that specifies which treatments currently seem most suitable for each infestation, depending upon their spatial context. For example, the map is color-coded to show that hand-pulling is preferred near residences and areas of special ecological concern, namely the Quarry pond for its rare vernal pool plant. High-traffic areas and areas mowed for fire safety are coded to show that Calendula should be hand-pulled before mowing, and then the mower must be pressure-washed to prevent Calendula from spreading to other parts of the Preserve.

The stitch to stop the fray

There is no doubt that Calendula has a strong presence in Sonoma Valley. Because of this, it would be unrealistic to think that we could eradicate it completely from Bouverie Preserve. However, we are beginning to understand the range of tools that we can rely on to control and contain the infestations. Although our investigations remain inconclusive, our field observations have highlighted important questions:

1. How long does the seedbank of Calendula persist? Understanding seed longevity in the soil will help us know how many years we need to revisit treatment sites before we can expect eradication.

2. What is the range of moisture and shade tolerances of Calendula? Learning about site tolerances can help us to anticipate potential areas of Calendula expansion and improve our strategies for management.

3. To what extent does Calendula impact native grasses and forbs? In areas that are less suitable for Calendula, the impacts on native plants may be less critical, allowing us to consider it a lower priority than other management needs in those areas.

4. Is there a native plant or non-seeding grass that could be used to outcompete Calendula? If we can identify a less-noxious species that can compete with Calendula, we may be able to scatter its seeds in a former Calendula area to prevent reinvasion or prevent invasion in bare-soil areas.

Addressing some of the questions above may lead to new information, not only about Calendula but also about weed ecology in general. As environmentally concerned humans, we seek timely answers to stop the environmental fabric from unraveling. Lessening the edge effect requires cooperation from adjacent landowners, intensive invasive-plant management, and concurrent restoration activities. But it is also important to step back, assess, and ask questions. In a time of rapidly expanding edges between developed and natural areas, having an intimate understanding of non-native invasive plants is crucial in designing ways to curb ecological impacts, or to find the right stitch to stop the fray.

We extend our special thanks to the Bouverie Stewards, Bouverie Preserve Land Steward John Martin, intern Ashley Poggio, and other volunteers who have assisted with *C. arvensis* control at the Bouverie Preserve.

References cited

Booth B., S.D. Murphy, and C. J. Swanton. 2003. Weed Ecology in Natural and Agricultural Systems. Oxford University/CABI Press, Cambridge MA. 303 pp.

Ruiz de Clavijo, E. 2005. The reproductive strategies of the heterocarpic annual Calendula arvensis (Asteraceae). Acta Oecologica 28:119-26.

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MATTHEW DANIELCZYK

New ACR Sanctuary

In May, 2012, 1,620 acres of wild and natural lands were transferred from the National Audubon Society to Audubon Canyon Ranch, establishing ACR's new Mayacamas Mountains Sanctuary (MMS) in the rugged and remote central Mayacamas Mountains of northern Sonoma County, northeast of Healdsburg.

By protecting the MMS in perpetuity, ACR will ensure that neighboring landowners and local communities continue to benefit from healthy communities of native plants and animals and the clean water, clean air, and healthy soils that sustain them. One way to view these benefits is through the "ecosystem services" provided by this natural landscape (see related story on page 4).

In Progress:
project updates

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

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

Tomales Bay Shorebird Census. ◗ Since 1989, we have conducted annual shorebird censuses on Tomales Bay. Each census involves six baywide winter counts and one baywide count each in August and April migration periods. The data are used to investigate winter population patterns, local habitat values, and implications for shorebird conservation. We are currently measuring benefits of the Giacomini Wetlands Restoration Project to shorebirds using Tomales Bay.

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 (http://www.egret.org/atlas) along with a Google-Earth program showing the locations and status of individual heronries (www.egret.org/googleearthheronries). We are currently working on the effects of climate change on regional nesting abundances, the effects of colony site disturbance on nesting distributions, and seasonal heron and egret use of Bolinas Lagoon.

Four Canyons Project. ◗ We are restoring native vegetation in the lower reaches of four canyons at ACR's Martin Griffin Preserve, controlling invasive plant species and using locally collected and propagated plant materials to repair disturbed sites.

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 leniscus)* 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.

Annual Surveys and Removal of Non-Native *Spartina* and Hybrids. ◗ ACR is collaborating 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 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 and new patches.

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. ◗ In the vernal pools at Bouverie Preserve, we are monitoring the federally listed Sonoma sunshine *(Blennosperma bakeri)*, the California species of conservation concern, dwarf downingia *(Downingia pusilla)*, and native plant populations. We are also removing invasive plants that encroach upon vernal pools, using manual removal and rotational cattle grazing.

Yellow Starthistle at Modini Ingalls Ecological Preserve. ◗ Sherry Adams conducted an inventory of yellow starthistle *(Centaurea solstitialis)*, established a monitoring program, and developed guidelines to reduce the spread of this invasive plant.

Serpentine and Rare Plant Survey at Modini Ingalls Ecological Preserve. ◗ Sherry Adams and volunteers are identifying and mapping unique plant assemblages associated with serpentine outcrops 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.

Project GROW. ◗ Gathering to Restore Oak Woodlands (GROW) is a partnership between ACR and the Southern Sonoma County Resource Conservation District to restore eight acres of oak woodlands at the Bouverie Preserve. Community members and Sonoma Valley High School students have helped plant five species of oak trees, thousands of native grass individuals and hundreds of native understory plants. Habitat enhancements include installing brush piles and nest boxes to support wildlife.

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.

Trail Improvements at Bouverie Preserve. ◗ We worked with volunteers and the Sonoma County Trails Council to enhance trails, installing rolling grade dips, building a rock causeway, and improving handicap access, and to prevent sediment from entering Stuart Creek.

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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.

Survival of wild adult female harbor seals (Phoca vitulina) *in San Francisco and Tomales Bays, California*. Susanne Manugian, Moss Landing Marine Laboratories.

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.

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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.

The Ardeid is published annually by Audubon Canyon Ranch as an offering to Conservation Science and Habitat Protection field observers, volunteers, and members. To learn more about this program and how to support Audubon Canyon Ranch, please contact the Cypress Grove Research Center (cgrc@egret.org or 415.663.8203) or ACR's headquarters (acr@egret.org or 415.868.9244).

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MARTIN GRIFFIN PRESERVE • CYPRESS GROVE RESEARCH CENTER
BOUVERIE PRESERVE • MAYACAMAS MOUNTAINS SANCTUARY

Calendula arvensis, a brilliant orange flower that commonly occurs in vineyards, has become an invasive pest at ACR's Bouverie Preserve.

MANUEL M. RAMOS

Stitching a Landscape see page 10