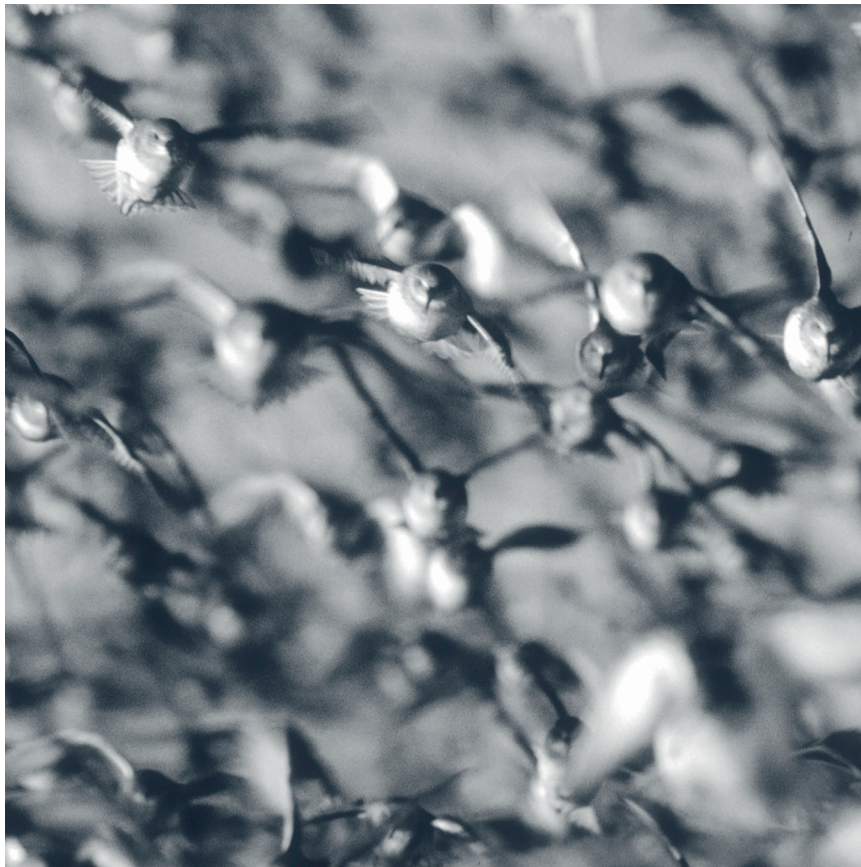




Research and
Resource Management
at Audubon Canyon Ranch

THE ARDEID



Vernal pools and
swales the
ecosystem
perspective
► Fire as a
management tool
a re-examination
► Dunlin in winter
energy in the
balance ► Ravens
and crows a
population
report ► Tidal marsh
progress watershed
effects ► Research
project updates

2001



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Cover photo: Dunlin flock by T. Fitzharris VIREO

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B = Breeding Birds at Bouverie Preserve ♦ C = Common Raven Study ♦ H = Heron/Egret Project ♦ I = Plant Species Inventories ♦ M = Livermore Marsh Monitoring ♦ N = Newt Survey ♦ P = Photo Points ♦ R = Habitat Restoration ♦ S = Tomales Bay Shorebird Project ♦ W = Tomales Bay Waterbird Census

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Developing an ecosystem perspective for seasonal wetland management

Vernal Pools and Swales at the Bouverie Preserve

by Rebecca Anderson-Jones

Once regarded as little more than mud holes or “hog wallows,” vernal pools and swales are now widely recognized as intrinsically valuable features of the broader ecological landscape. Yet these ephemeral wetlands present many challenges to the conservation land manager. Found across much of California, vernal pools and swales hold water through the winter and spring seasons, providing habitat for species that occur nowhere else. Vernal pool topography is often mounded or rolling, with pools forming in the depressions between elevated areas known as “mima mounds.” Some mima mounds rise only inches above the nearest

pool floor, while others may be much taller, measuring to a height of six feet. Adjacent pools are sometimes linked by a series of natural channels or swales. A hardpan underlying the soil restricts water percolation, producing saturated surface soils and prolonged inundation for the species that inhabit these depressions. Some species that depend on these habitats have been assigned special conservation status, including a host of flowering plants, amphibians, and invertebrates adapted to the harsh transition from inundation to desiccation that occurs as vernal pools and swales fill and dry. As we continue to study the pools and swales at the Bouverie Preserve, we do so with the awareness that an effective management strategy must take into account the characteristics that make this ecosystem unique.

Along the western boundary of the Bouverie Preserve, near Glen Ellen in the Valley of the Moon, seasonal wetlands encompass three interconnecting swales



Southernmost vernal pool at Bouverie Preserve, near Highway 12; March, 2001.

and two discrete vernal pools in a landscape dominated by native and introduced grasses and forbs. Subtle changes in elevation characterize the topography, with low mounds separating the nearly parallel swales distal from Highway 12. Adjacent to the highway, these swales converge into a broader perpendicular depression. A well-established oak planting project that also exists in this field, once managed exclusively as pasture, recreates features of an oak savannah that may have occurred on this site before agricultural use. In the regional park across the highway, yellow rings of Sonoma sunshine (*Blennosperma bakeri*), an endangered member of the sunflower family, demarcate a few small vernal pools. Similar patterns of color occur in the vernal wetlands at Bouverie in the spring (see photo). Although the historic relationship between the vernal wetlands at Bouverie Preserve and the vernal pools in the regional park is unclear, both systems lie within an area conservation plan-

ners describe as the Santa Rosa Vernal Pool Region (Keeler-Wolf et al. 1998. California vernal pool assessment. Prelim. Rpt. Calif. Dept. Fish and Game.).

The Santa Rosa Vernal Pool Region extends south from the Russian River into northern Marin County and east toward Sonoma, and it is comprised of many vernal wetland systems. Some of these pools contain state and federally recognized endangered endemics such as Burke's goldfields (*Lasthenia burkei*), Sebastopol meadowfoam (*Limnanthes vinculans*), and Sonoma sunshine. Many vernal pools and swales in the region have succumbed to, or are threatened by, changes caused primarily by human activity, including urban and agricultural expansion, the spread of nonnative, invasive plants, poor grazing management practices, altered hydrology due to irrigation, increased foot traffic, discing damage, and other disturbances.

Although vernal wetlands share many physical characteristics, the species com-

Continued on page 2

◆ *Vernal pools, continued*

Vernal swale at Bouverie facing west: March, 2001. In the foreground, the flowering stalks of velvet grass, *Holcus lanatus*, an invasive, nonnative grass at the east end of the swale. In the center of the picture, a vernal swale is bordered by light bands of flowering *Limnanthes douglasii*. In the left background, the entrance driveway across the highway leads to the Sonoma Valley Regional Park, where the endangered *Blennosperma bakeri* grows in vernal pools.

position of vernal pools and swales can vary significantly across landscapes and even between adjacent pools and swales in the same system. An expanded inventory of the plants, invertebrates, and amphibians as well as hydrologic and geologic profiles will be developed for the pools and swales at the Bouverie Preserve. This information will be used as we develop a new grassland management plan incorporating wetland conservation goals.

Data regarding species composition of the Bouverie Preserve wetlands are currently limited to a partial flora compiled from occasional, informal surveys of the pools, swales and adjacent uplands by ACR volunteer and staff botanists Phyllis Ellman, Grant Fletcher, Greg deNevers, and Rebecca Anderson-Jones. This list (Table 1) includes many wetland indicator species such as coyote thistle, iris-leaved rush, meadowfoam, and tiny glue seed, a common relative of the endangered composite found across the road. A few nonnative and potentially invasive wetland weeds also thrive here. Pennyroyal is found here and also in ditches and wet depressions bordering agricultural lands elsewhere in Sonoma and Marin counties, in vernal pools and meadows in the Laguna de Santa Rosa floodplain, along the edges of the Estero Americano, and along the banks of the Petaluma River. Velvet grass is an invasive, introduced perennial grass that competes with pennyroyal as well as with native wetland vegetation along the eastern margin of the swales here, and it is common in

moist coastal and inland fields. The introduced hyssop-leaved loosestrife is a less invasive congener of the infamous purple loosestrife, a plant that has created significant management problems in the Sacramento Delta and other waterways throughout the state.

Managing a unique system

Left unchecked, many nonnative plants, including grasses such as velvet grass and medusahead, and forbs such as those described above can pose significant threats to vernal pool ecosystems. These threats include direct displacement of native plants along pool and swale margins, as well as displacement of native vegetation in the centers of pools and swales during dry years. In addition, introduced annual grasses drain soil moisture earlier in the growing season than their perennial native counterparts, and they produce large quantities of thatch that can accumulate, decreasing runoff. Both of these effects give introduced annual grasses the potential to significantly alter the hydrologic profile of the landscape. In addition, the accumulation of thatch from annual grasses can limit light penetration, decreasing the competitive success of many native plants. Although long-term intensive grazing has been associated with the decline of "floristic quality" in many vernal pools across the state (Keeler-Wolf et al. 1998), carefully managed grazing is also recognized as a valuable strategy for reducing the impacts of nonnative grasses

on the indigenous flora and the hydrology of seasonal wetlands and the uplands associated with them (Barry 1998, in Witham et al., eds. 1998. Ecology, conservation, and management of vernal pool ecosystems. Proc. 1996 CNPS Conf.).

Ideally, to manage vernal wetlands in a grassland dominated by introduced annuals, one would begin a light grazing regime early in the year. This would prevent the build-up of excessive biomass, ease the competitive pressure for many native plants, and keep some of the most noxious invasive annual grasses, such as medusahead, from setting seed.

However, the presence of

grazing animals can adversely affect ground-nesting birds in the adjacent uplands, and this has been a concern at the Bouverie Preserve. Here, Red-winged Blackbirds typically breed and nest in the tall grasses and forbs near the vernal pools and swales from the end of February through early May. To avoid disrupting the birds at this crucial time, a

Close-up from the east end of the central swale: March 2001. Three competing species: *Limnanthes douglasii*, a native meadowfoam in the foreground, *Mentha pulegium*; the creeping, invasive, nonnative pennyroyal above that; and the invasive, nonnative velvet grass, *Holcus lanatus*, in the background.



long-term grazing regime was implemented years ago that began in late spring and continued through the summer months. However, after upland grasses dried and became significantly less palatable, vernal pool and swale plants remained moist. As a result, certain wetland plants were preferentially grazed late in the season, and some areas of the swales were eventually overgrazed.

Grazing can create other management challenges as well. Where grazing pressures are intense, the least palatable and often less desirable species, like medusahead, pennyroyal, or turkey mullein (*Eremocarpus setigerus*), may become dominant. For this reason, monitoring can be an important component of a veg-

etation management project that relies on grazing. An additional consideration is the effect of nitrogen enrichment where livestock graze. The impact of nutrient enrichment on vernal pool and swale species is uncertain, although concerns have been raised that resulting biotic changes, including algal blooms, could have a detrimental effect on some vernal pool plants, including the endangered Contra Costa goldfields (*Lasthenia conjugens*; Ornduff 1995, in Dept. of Int. U.S. Fish and Wildlife Final Rule, Endangered status for four plants from vernal pools and mesic areas in northern California. Fed. Reg. June 18, 1997). Land managers at Jepson Prairie in Solano County, have tested a combination of early season

grazing and late spring burns to control medusahead and manage annual grass biomass. Their results suggest that fire also has a great deal of potential as a tool for managing vernal wetland and associated grassland vegetation (Pollak and Tan 1998, *in* Witham et al. 1998).

Managing vernal wetland landscapes to favor native biodiversity is a challenge that requires an informed, creative and adaptive approach. We continue gathering information about vernal wetland management efforts and the Bouverie Preserve wetland system, and we look forward to developing a management plan that will incorporate strategies for protecting the biotic and hydrologic character of this unique ecosystem. ■

Table 1. A partial flora of the vernal swales and pools at Bouverie Preserve. **OBL** = obligate wetland species; almost always occur in wetlands under natural conditions. **FACW** = usually occur in wetlands but occasionally found in other areas. **FACU** = usually occur in non-wetlands but occasionally found in wetlands. Where two categories have been applied, species, ecotypes or subspecies vary in response to wetland habitat requirements. * Indicates introduced species. Indicator categories derived from the U.S. Fish and Wildlife Service, National List of Vascular Plant Species That Occur in Wetlands: 1998.

Family name	Binomial name	Common name	Indicator category
Apiaceae	<i>Eryngium</i> sp.	coyote thistle	OBL; FACW
Asteraceae	<i>Blennosperma nanum</i>	tiny glue seed	OBL
Campanulaceae	<i>Downingia concolor</i>	no common name	OBL
Crassulaceae	<i>Crassula aquatica</i>	no common name	OBL
Cyperaceae	<i>Eleocharis</i> sp.	spike rush	OBL; FACW
Juncaceae	<i>Juncus bufonius</i>	toad rush	FACW; OBL
Juncaceae	<i>Juncus xiphioides</i>	iris-leaved rush	OBL
Lamiaceae	<i>Mentha pulegium</i> *	pennyroyal	OBL
Liliaceae	<i>Triteleia hyacinthina</i>	white hyacinth	FACW
Limnanthaceae	<i>Limnanthes alba</i>	white meadowfoam	OBL
Limnanthaceae	<i>Limnanthes douglasii</i>	meadowfoam	OBL
Lythraceae	<i>Lythrum hyssopifolia</i> *	loosestrife	FACW; OBL
Poaceae	<i>Deschampsia danthanioides</i>	annual hairgrass	FACW
Poaceae	<i>Glyceria occidentalis</i>	western mannagrass	OBL
Poaceae	<i>Holcus lanatus</i> *	velvet grass	FACU; FACW
Poaceae	<i>Hordeum brachyantherum</i>	meadow barley	FACW
Poaceae	<i>Pleuropogon californicus</i>	semaphore grass	OBL
Poaceae	<i>Polypogon maritimus</i> *	Mediterranean beardgrass	OBL
Poaceae	<i>Taenicum caput-medusae</i> *	medusahead	FACU ¹
Polemoniaceae	<i>Navarretia intertexta</i>	no common name	FACW; OBL
Portulacaceae	<i>Montia fontana</i>	water chickweed	OBL
Primulaceae	<i>Centunculus minimus</i>	chaffweed	OBL; FACW
Ranunculaceae	<i>Ranunculus muricata</i> *	spiny buttercup	FACW
Scrophulariaceae	<i>Gratiola ebracteata</i>	hedge-hyssop	OBL
Scrophulariaceae	<i>Mimulus guttatus</i>	seep-spring monkeyflower	OBL
Scrophulariaceae	<i>Veronica peregrina</i> ssp. <i>xalapensis</i>	purslane speedwell	OBL

¹Adapted from Crampton (1974. Grasses in California, U.C. Press).

Energy conservation in wintering Dunlin

Balancing Acts

by John P. Kelly

It is a common understanding in the San Francisco Bay area that there has never been an average winter. That is, winters vary dramatically in both the cumulative extent and pattern of seasonal rainfall. Even without droughts or floods, rainfall needed to invigorate and sustain coastal watersheds may be delivered by prolonged periods of gentle precipitation or, alternatively, by a few fierce winter storms. It seems impossible to predict our winter weather. Nonetheless, wintering shorebirds must contend with this uncertainty, because rainstorms, wind, extreme high tides, and pulses of freshwater runoff strongly influence both thermal and foraging conditions.

Increases in freshwater runoff can cause estuarine invertebrates to recede deeper into the mud, beyond the reach of probing sandpipers. During periods of heavy runoff, prey populations decline. Strong winds may further alter the behaviors of prey, reducing their detectability to shorebirds. During severe or extended storms, birds may use more energy than they can obtain by feeding, increasing risks of starvation and predation. Such risks structure complex adaptations that underlie the wonder of these "wind birds."

To improve their chances of winter survival, shorebirds maintain energy stores in the form of fat and protein that can be mobilized to provide fasting endurance during periods of extreme cold or food

scarcity. The use of alternative feeding areas during such times may be crucial. In a reciprocal translocation of color-banded Dunlin (*Calidris alpina*) between northern and southern Tomales Bay, displaced individuals quickly returned to and remained in the vicinity of their sites of capture. Thus, under normal wintering conditions, they exhibit a relatively small range of movement. However, Dunlin also exhibit non-migratory mid-winter flights to interior wetlands in the Central Valley (Warnock et al. 1995. Wilson Bulletin 107: 131-139). The timing of these flights coincides with the seasonal development of wetlands in the interior, as well as with deteriorating feeding conditions along the coast. So Dunlin may depend on activity expenditure (regional flight capacity) as well as storage of reserve energy to adaptively respond to changing risk of winter starvation. But what adaptive wisdom guides how these birds choose between storing and using energy?

Storing energy in reserve body tissue involves a trade-off between the costs and benefits of fattening (Figure 1). Although storing fat reduces starvation

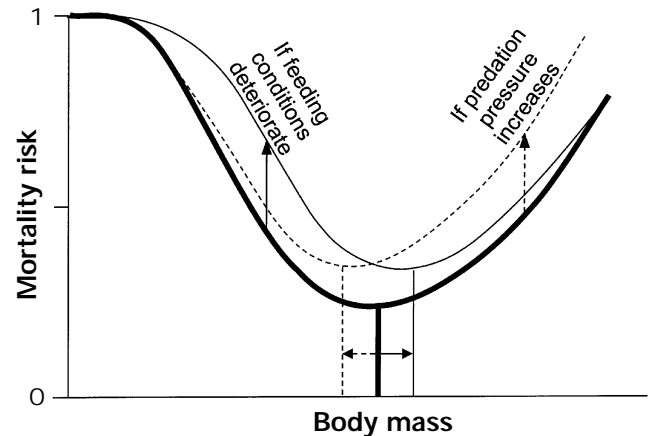


Figure 1. Theoretical effects of body mass on mortality risk. As birds increase body mass by storing more energy (primarily as fat), starvation risk declines, but predation risk increases if birds become overweight (bold line). Optimum body mass occurs when mortality risk is minimized, at intermediate levels of energy storage. If feeding conditions deteriorate (thin line), optimum body mass increases (shifts right); if predation pressure increases (dashed line), optimum body mass declines (shifts left).

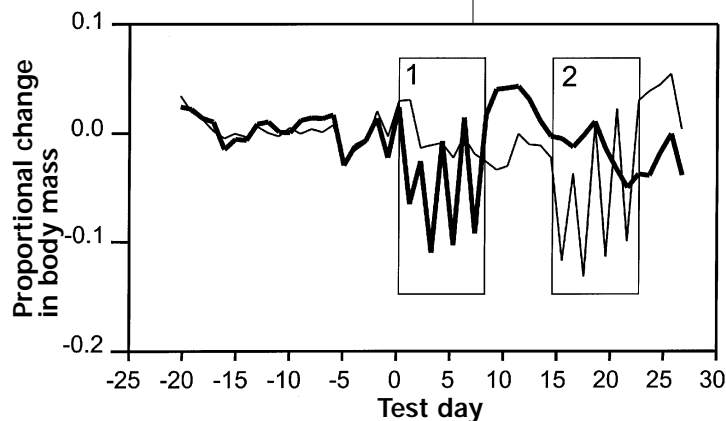


Figure 2. Daily body mass change in food-restricted Dunlin relative to controls provided with continuously available food (ad libitum). Boxes indicate test periods of restricted 24 hour:24 hour (fasting:ad libitum) feeding. Treatment group was switched between test periods. Box 1: bold line = restricted birds (n=7); thin line = controls (n=7); Box 2: bold line = controls; thin line = restricted. All birds were provided with continuously available food outside of test periods.

risk, the associated gain in body mass increases the cost of flight and reduces a bird's ability to evade predator attacks. Therefore, birds should increase energy stores if possible whenever food is likely to become less available and reduce energy stores as foraging conditions improve.

Other investigators have provided evidence that some shorebird species such as Black-bellied Plover (*Pluvialis squatarola*) and Redshank (*Tringa totanus*) can recover body mass lost during periods of negative energy balance (Dugan, et al. 1981. Ibis 123: 359-363). Similarly, Oystercatchers (*Haematopus ostralegus*) forced to forage for shorter periods of time compensate by increasing food intake to a level that maintains the same mean consumption over a longer period (Swennen et al. 1989. Animal Behaviour 38: 8-22). A more effective adaptation, however, would be the ability to increase body mass reserves in anticipation of periods of energy shortfall. In recent work on Tomales Bay, I found evidence that Dunlin regulate body mass in response to the arrival of winter storms that can signal loss of feeding opportunities. However, shorebirds might manage their energy reserves more effectively by responding only to periods of actual food scarcity, as imposed by extended flooding of mudflats or by storm-related declines in prey populations. How do shorebirds respond when feeding opportunities are severely restricted?

Wintering shorebirds cannot save energy by temporarily reducing their resting metabolism, as in the nightly torpor of hummingbirds, because it would interfere with their need to actively forage and evade predators both day and night. To conserve or enhance energy stores, shorebirds might increase in their food intake, decrease the amount of energy spent on activities, or reduce heat loss. Most shore-

bird species expend over half of their daily energy requirement just generating enough heat to maintain internal body functions. Birds may conserve body heat by tucking bills or legs into their plumage, seeking sheltered habitats, or standing in the lee of other individuals to avoid wind chill. But because such thermoregulatory behaviors are important in shorebirds at all times, there is little opportunity to increase energy savings through additional behavioral thermoregulation during winter storms. To adjust and readjust their energy stores to fluctuating risks of starvation and predation, shorebirds are most likely to alter the amount of energy used for activities and/or the amount of food consumed.

Effects of food scarcity

Shorebirds in coastal habitats normally depend on feeding areas that are suitable only during intermittent low tides. Available foraging time is further reduced when winter storms, flooding, or sedimentation prevent successful foraging or access to feeding areas. By observing the responses of aviary Dunlin to periodic feeding constraints such as those imposed by winter storms, I tested the prediction that Dunlin regulate body mass by increasing energy stores when available feeding time is reduced and decreasing energy stores when feeding time is extended (Figure 2). I used fixed schedules of fasting and unrestricted (ad libitum) feeding to simulate food restriction experienced by wintering shorebirds during unusually high tides or heavy storms. The Dunlin were captured on Tomales Bay and held temporarily in aviaries at ACR's Cypress Grove Research Center. They were provided with freely available food (trout chow) and water. Except during periods of enforced fasting, they maintained body weights that were slightly greater than weights maintained in the field. The aviary birds never experienced even the early stages of starvation, because fat reserves were never depleted. The birds were released after measurements were completed, prior to spring migration.

When aviary birds were allowed to feed only on alternate days, they significantly increased their body mass relative to controls (Figure 2). Increases in minimum body mass on successive fasting days indicated that true fattening occurred in spite of temporary periods of weight loss. When daily feeding was restored, body mass in food-restricted individuals continued to increase for two or three days, then declined toward con-

trol levels. So when faced with possible food shortage, birds gained weight.

In additional tests, more severely restricted birds increased their energy stores at even greater rates. This suggests, not surprisingly, that birds perceive a greater risk of starvation under greater food restriction, such as might occur during more severe winter storms. Differences in regulated levels of reserve energy further indicated that individual birds differ in their perceptions of optimal body mass (Figure 1)—a dimension of variation upon which natural selection might act.

Dunlin under a restricted feeding regime consumed more food than birds allowed to feed continuously, but the additional amount of energy consumed was insufficient to account for their increased body mass. Increased energy storage was therefore partly achieved by reducing activity costs.

Because energy intake and use must balance, I was able to estimate the energy birds used for activities by deduction, from measurements of food intake, thermal and resting metabolism, and energy retained or lost in stored body tissues. I used taxidermic Dunlin mounts with hollow copper bodies as thermometers to measure the temperatures (adjusted for wind speed and solar radiation) that birds would experience if they produced no metabolic heat, and from these I calculated the amount of energy birds need to stay warm.

The results suggested that, when feeding opportunities are restricted, Dunlin try to increase food intake and energy stores (Figure 2) and also become less active (Figure 3). When feeding is not possible, however, they become more active than birds accustomed to more suitable feeding conditions (see Figure 3 at Gross energy intake=0). This enhanced activity is consistent with regional midwinter flights to new wintering areas during periods of heavy rainfall, as well as with broader use of local foraging alternatives during winter storms (See *The Ardeid*, Spring 1999). In contrast, birds accustomed to unrestricted feeding opportunities may choose to "ride

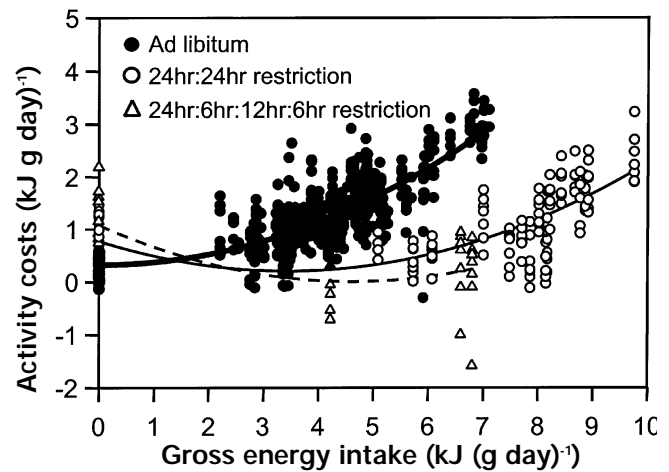


Figure 3. Food-restricted Dunlin reduced their activity and increased their energy intake when allowed to feed, relative to controls, but increased their activity when forced to fast (at Gross energy intake=0). Solid circles = ad libitum fed birds; open circles = 24 hr:24 hr (fasting:ad libitum) restricted birds; open triangles = 24 hr:6 hr:12 hr:6 hr (fasting:ad libitum:fasting:ad libitum) restricted birds.

out" an unusual winter storm by reducing activity costs while fasting until normal conditions return (see Figure 3 at Gross energy intake=0).

Birds are known to respond to a wide range of environmental stressors by increasing plasma levels of corticosterone, an adrenal hormone involved in emergency use of energy stores as well as in winter fattening. The secretion of stress hormones can be stimulated by inclement weather or disruption of normal feeding patterns. This raises an interesting possibility—that endocrine-mediated responses to changing energy stores, weather, and foraging conditions might enable shorebirds to maintain appropriate amounts of stored energy or might stimulate movements of shorebirds to alternative feeding areas. However, the relative importance of physiological cues is not clear.

More work is necessary to determine the extent to which these patterns occur in free-living shorebirds. The relationship between the regulation of energy stores and activity levels may be crucial in understanding midwinter shorebird movements and the thresholds of shorebird use in estuaries like Tomales Bay. ■



Monitoring the return of tidal influence on a coastal wetland

Marsh Revival

by Katie Etienne

GRAPHIC BY LAUREN HAMMACK

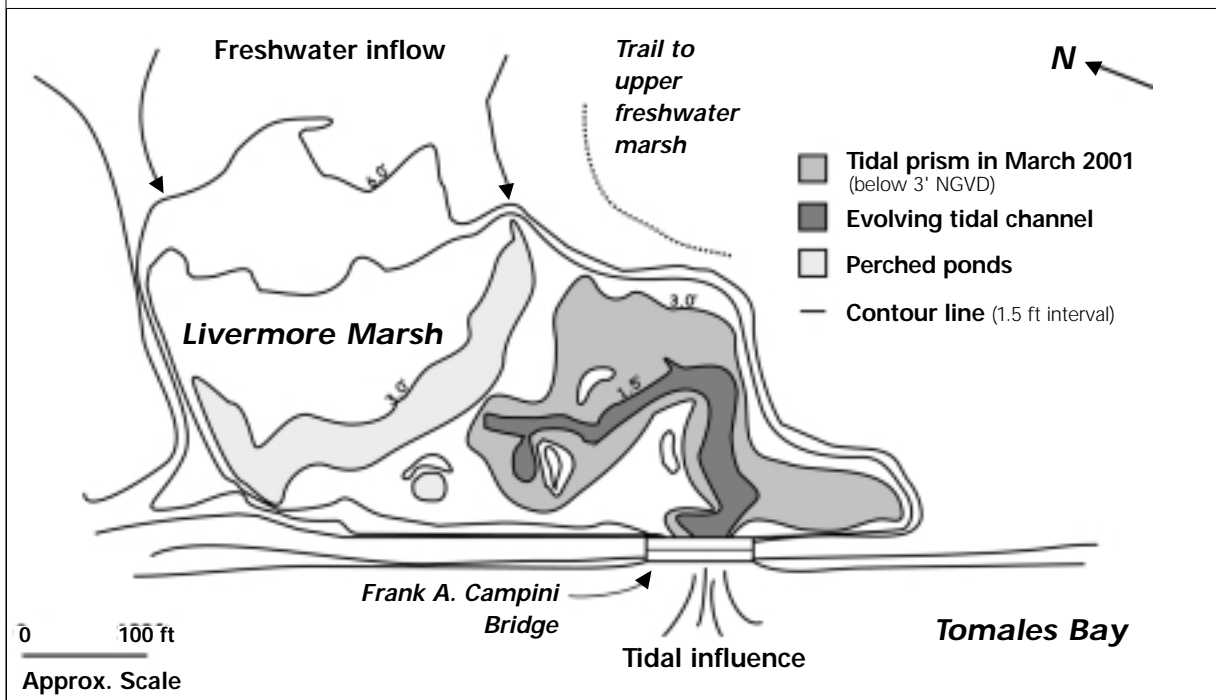


Figure 1. Features of evolving tidal marsh at Audubon Canyon Ranch–Cypress Grove Preserve.

Since the dramatic breach of the old North Pacific Coast Railroad levee at Cypress Grove Preserve (CGP) in 1998, a research project has been underway to study the transformation of Livermore Marsh. With financial assistance from the Marin Community Foundation, Audubon Canyon Ranch developed a five-year research project to monitor several physical and biological parameters associated with the reintroduction of tidal circulation into the perched freshwater marsh.

The primary objectives of this study are to document the rate and timing of geomorphic changes during the development of this tidal marsh and to compare Livermore Marsh to mature coastal marsh systems. Four topographic surveys of the marsh and its developing features have been completed to date. In May 1998, Kamman Hydrology and Engineering (KHE) volunteered to survey the 86-foot levee breach and the new tidal channel. Pacific Land Surveys (PLS) delineated the general topography and physical features of the marsh plain in May 1999. The PLS survey includes more than 5,000 point

elevations along ten north-south transects that are used to identify one-foot contours. Additional points indicate the location and shape of the primary tide channels, some of the secondary channels, and major stands of marsh and riparian vegetation. The points were reported in three standardized coordinate systems (NAVD88; NOS and NGVD29) that allow us to compare the changing topography of Livermore Marsh with other coastal marsh systems. The PLS survey also established control points for future surveys, to document the evolution of the tidal marsh.

The area of the tidal inlet has gradually decreased since 1998. Subsequent tides and winter runoff

ly measurements from the bridge during the ebb flow of a median tide. A carpenter's laser level and a bicycle reflector mounted at the north and south ends of the bridge provide a standard horizontal reference for measuring channel depth with a telescoping measuring rod. As of February 2001 the area of the tidal inlet is 80 ft², which represents a 72% decrease in area since May 1998 (Table 1). To evaluate

have moved and reworked sediment in the marsh and filled the large scour hole in the tidal inlet. Four defining characteristics of the tidal marsh at CGP have been analyzed from sequential topographic surveys: tidal inlet area, tidal channel length, tidal channel volume, and tidal prism volume (Table 1).

To document seasonal changes in the cross-sectional area of the tidal inlet, I conduct month-

Table 1. Geomorphic characteristics of Livermore Marsh at Cypress Grove Preserve.

Survey Date	Tidal Inlet Area below 3 ft NGVD (sq. ft.)	Tide Channel Length estimated (ft.)	Tide Channel Volume below 1.5 ft. (acre-ft.)	Tidal Prism Volume below 3 ft NGVD (acre-ft.)
May 1998	283	230	0.32 ¹	1.4
Nov. 1999	176	470	0.39	1.6
Mar. 2001	80	580	0.48	2.0

¹Tide channel volume in 1998 was probably slightly larger than could be determined during this preliminary survey.

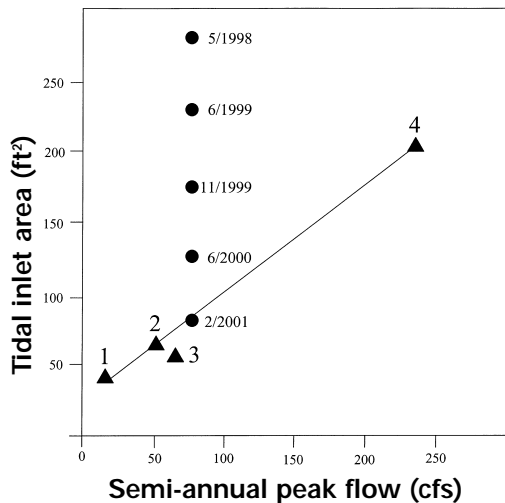


Figure 2. Relationship between discharge and tidal inlet area at four reference marshes along the east shore of Tomales Bay. 1=Pocket marsh at Walker Creek Delta, 2=Marshall Marsh, 3=North of Bivalve, 4=Millerton. Circles show a rapid decrease in inlet area at Livermore Marsh over 2.5 years.

the effect of extreme tides on channel inlet geometry, I also measure the inlet during extreme tidal events (spring and neap tidal cycles). These measurements are conducted three times during each year: before the rainy season begins, during the winter after eight inches of cumulative rainfall, and at the end of the rainy season. So far, extreme tides have not had a significant influence on inlet geometry.

While the length of the primary tide channel continues to increase in Livermore Marsh, the tide channel volume has not increased at a comparable rate, because the tide channels are becoming shallower. Tidal prism volume has increased by 0.6 acre-ft since 1998. This value reflects the increased volume of the primary channel and the "capture" of a pond that was previously isolated from the channel. The geomorphic characteristics of the tidal marsh at Cypress Grove are controlled by the sediment supply in the marsh, by runoff and sediment inflow from the watershed, and by the exchange of tidal flow within the tidal prism (see sidebar). As the system develops we expect to see: (1) continued infilling of the tidal inlet; (2) yearly growth of the tidal channel in both length and width; and (3) increased tidal prism volume. However, exactly when Livermore Marsh will reach dynamic equilibrium, and what the range of values for each of these marsh features will be, depends on the unique combination of physical and biotic factors operating within the marsh. Two possible perturbations of the system that we cannot predict, earthquakes and changes in sea

level, could dramatically alter the shape and volume of tide channels and the tidal prism.

Understanding the relationship between tidal prism and inlet geometry is an important tool for engineers and restoration biologists planning to breach man-made or natural obstructions to tidal circulation and freshwater runoff. To predict the future topography of Livermore Marsh, we surveyed the tide channel inlets and marsh plain elevations at older levee marshes on Tomales Bay. We compared these data with results from eight San Francisco Bay marshes in Napa and Sonoma counties (Coates et al. 1995, Philip Williams Assoc. Report No. 934) to predict relationships between cross-sectional area of tidal inlets and tidal prism.

Although the inlet area of Livermore Marsh was larger in 1999 than predicted, by February 2001 it was 80 ft²—significantly smaller than the 112 ft² predicted from regressions based on tidal marshes in San Francisco Bay (Coates et al. 1995). There were also major differences between the size of the tidal inlets at reference marshes in Tomales Bay and predicted values from the regressions for eight San Francisco Bay marshes. These differences appear to be most pronounced for the Tomales Bay marshes with the smallest watersheds. For example, at a small marsh adjacent to Walker Creek delta (watershed 1.24 km²), the inlet area is 20% of the size predicted from Coates et al. (1995). The inlet of a slightly larger marsh located north of Bivalve (watershed 2.41 km²) is 23% of

the predicted size. Comparison of the marsh at Millerton Gulch (watershed 9.63 km²) reveals an inlet area that is 51% of the predicted size.

Discharge incorporates the effect of watershed size, slope, permeability and local precipitation patterns. I compared discharge data for the Tomales Bay reference marshes with the tidal inlet area (calculated below 3 ft NGVD; Figure 2). Although this regression should be interpreted cautiously, because it is based on only four marshes, the data suggest that the inlet area increases 78 ft² for each 100 ft³ per second of discharge (Figure 2; R²=0.98; P<0.01). Note the rapid reduction in inlet area for Livermore Marsh during the 2.5 years following the levee breach. If freshwater discharge were the only factor influencing inlet cross-section size, one could predict that the cross-section of the tide channel would be approximately 80 ft² at equilibrium.

Watershed size and discharge may not be the only difference between marshes in Tomales Bay and San Francisco Bay. It is possible that the highway and railroad levee along the east shore of Tomales Bay impede the movement of sediment from east shore watersheds and contribute to the relatively high marsh plain elevations and incised channels that characterize Tomales Bay marshes. While attempts to measure and predict natural processes often generate more questions than answers, they provide opportunities for new insight into fundamental relationships among physical and biotic processes, and they support better stewardship of coastal marsh ecosystems. ■

Physical and biological effects on marsh topography:

- ▶ The major factor influencing coastal marshes is tidal amplitude, which is moderated by weather patterns and subtidal topography.
- ▶ Tidal action and geologic characteristics of the watershed influence erosion, transport, and deposition of sediment within the marsh.
- ▶ Freshwater runoff influences the length and depth of tide channels as well as salinity gradients that affect the type and distribution of marsh vegetation.
- ▶ Vegetation patterns and root systems can modify tide-channel geometry.
- ▶ Benthic invertebrates and burrowing mammals can influence marsh and levee erosion.
- ▶ Changes in climate and sea level can increase tidal prism and influence marsh topography.
- ▶ The exchange of tide water in a marsh can be described in several ways: *Tidal prism* represents the total volume of water that flows in and out of a tidal inlet with the movement of the tide, excluding any freshwater input. *Actual Tidal Prism* is based on measurements of marsh topography and actual or predicted tidal statistics. *Potential Tidal Prism* is the volume of water that would exist between mean high-high-water (MHHW) and mean-low-low-water (MLLW) if there was no sediment between these elevations.

Abundance and distribution of Common Raven and American Crow in the San Francisco Bay area

'The Birds'

by John P. Kelly

Recent local increases in the abundances of Common Ravens (*Corvus corax*) and American Crows (*Corvus brachyrhynchos*) have caught the attention of birders in many parts of the San Francisco Bay area. Occasionally, general impressions of corvid population growth and fears of increasing nest predation on other native species have tempted Hitchcock-like fears about the future status and ecological roles of these species.

Of particular concern to Audubon Canyon Ranch is whether increases in the numbers of ravens and crows might signal severe increases in nest predation or disturbance of colonially nesting waterbirds such as herons and egrets. In response to these concerns, we began a study of local raven populations. The study involves radio telemetry to track the movements of nesting ravens in Marin County and substantial efforts to observe nest predatory behaviors of Common Ravens at heronries. As part of this study, we conducted a series of road surveys to determine the status of ravens and crows in our region (Figure 1).

From March through June 1999, we recorded the occurrences of Common Ravens and American Crows on 18 survey routes, averaging 49 km in length, established along roads. Routes were selected to represent open/rural or urban/suburban habitat, and interior, outer coast, or San Francisco Bay shore locations throughout the region, maximizing the distances among routes. To keep survey

speed down, we avoided free-ways and major highways.

Forty qualified volunteer observers conducted mid-morning road surveys twice monthly along each route. Survey teams consisting of one driver and one observer traveled at speeds of 35–45 mph. For each Common Raven or American Crow observed, we recorded the location (distance) along survey route, the perpendicular distance and direction from road, species name, group size, flight direction, and behavior (flying, perching, walking/

standing). We used the number of birds observed per kilometer of survey route to index corvid densities. We then examined differences between rural and urban/suburban habitats, and among coastal, interior and bay shore locations.

On average, $89\% \pm 2.3$ (std. error) of ravens and $92\% \pm 1.8$ of crows were observed within 200 m of survey routes. Most ravens ($69\% \pm 4.4$) and crows ($70\% \pm 7.1$) were observed within 100 m of survey roads. Ravens and crows observed at greater

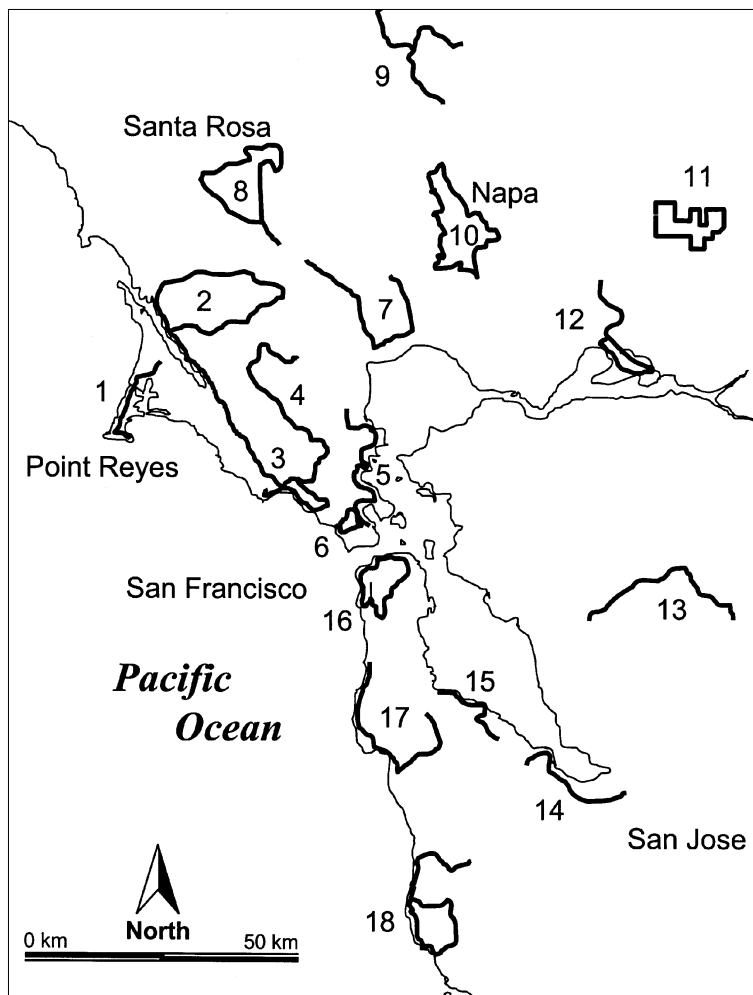


Figure 1. Routes used in Audubon Canyon Ranch road surveys of Common Ravens and American Crows in the San Francisco Bay area. Labels are route identification numbers.

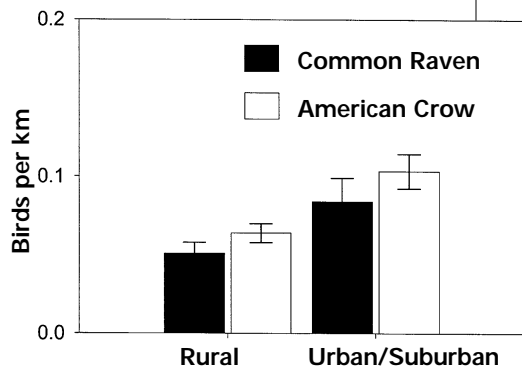


Figure 2. Mean number of Common Ravens and American Crows observed per km of survey route in rural and urban/suburban land use areas in the San Francisco Bay area. Values for American Crow exclude Route 11 (see text). Error bars = standard errors.

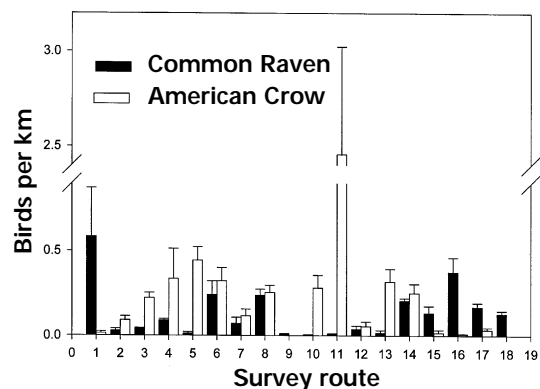


Figure 3. Mean number of Common Ravens and American Crows observed per km of survey route in the San Francisco Bay Area. Error bars = standard errors. See Figure 1 for route locations.

distances seemed to be as conspicuous as those closer to the road, suggesting that both species concentrated along roads. Concentrations of corridors along highways may reflect their habits of foraging on highway-generated carrion.

Hot spots, cold spots

Corvid numbers differed more greatly among survey routes than among surveys within each route, indicating significant regional variability in abundances of both ravens and crows. However, differences among coastal, interior, and bay shore location types were often no greater than among individual routes, indi-

indicating that more localized habitat features might determine the general pattern in the region. If so, corvid distribution may reflect an underlying array of local conditions that determine suitability for foraging or breeding. If not, these patterns may reveal localized opportunities for further population growth. The proportion of crows or ravens that occurred in pairs, suggesting possible breeding status, did not differ significantly among general land use types, subregional locations, or routes.

Densities of Common Ravens were significantly greater along urban/suburban survey routes than along rural survey routes (Figure 2). However, the highest numbers of ravens occurred near dairy ranches in the pastoral zone of the Point Reyes National Seashore (Figure 3). Because ravens are widely known to specialize on carcasses found on ranches, this is not surprising. The road surveys also indicated that Common Ravens occur in significantly greater densities along the outer coast than in either the interior of the region or along the bay shore (Figure 4). Interestingly, ravens were relatively abundant in San Francisco. Concentrated raven use of coastal and agricultural areas is matched by their ability to also exploit the most urbanized habitats surrounding San Francisco Bay.

Table 1. Breeding Bird Survey trends and mean number of birds per survey route for Common Raven and American Crow in the San Francisco Bay area. See Figure 5 for route locations. Significant linear trends are indicated by * $P < 0.05$, ** $P < 0.01$.

BBS route	Period	N years	Common Raven		American Crow	
			Trend % per year	Mean birds per route	Trend % per year	Mean birds per route
14	1968-2000	31	-3.27	0.55	2.33**	20.48
15	1969-2000	27	-11.12	2.52	10.00	1.81
16	1968-2000	18	6.80	6.39	19.92	1.17
71	1971-2000	24	1.82	20.75	6.45	7.83
83	1975-2000	17	1.34	17.18	0.36	7.65
172	1972-2000	19	-10.92	4.05	0.00	0.05
186	1972-2000	28	9.07**	52.50	0.32	1.86
187	1972-1988	14	0.00	0.21	12.30**	24.78
189	1972-2000	20	3.04	25.30	9.42	0.45
193	1972-2000	25	19.89*	1.12	-5.40**	8.88
194	1972-1995	23	-1.40	0.07	18.10*	0.52
202	1972-1997	26	0.12	29.54	10.93**	4.81
203	1972-1991	20	13.07**	13.30	-6.83	0.15
303	1992-1999	7	-8.13**	124.43	6.75	6.43
319	1992-1996	5	0.00	0.00	37.02*	18.20

American Crows were significantly more abundant along urban/suburban survey routes than along rural survey routes (Figure 2), with a striking exception in the open agricultural area south of Fairfield, where unusually high numbers occurred (Route 11, Figure 3). Densities of crows were significantly lower along the outer coast than in other subregions. With the exception of Route 11, densities of crows did not differ between bay shore and interior routes (Figure 4). According to survey results, crows seem to thrive in urbanized habitats throughout our region.

Consistent patterns and trends

We are examining other existing data to determine regional trends in the numbers of ravens and crows and to compare with patterns suggested by the road survey data. The North American Breeding Bird Survey (BBS) is an extensive roadside survey, based on 50 three-minute point counts conducted along each of thousands of 24.5-mile routes over much of North America. Because BBS surveys date back as far as 1966, they provide a perspective on changes in

regional abundance. The BBS is managed by the U. S. Geological Survey and Canadian Wildlife Service (see the web site at www.mbr-pwrc.usgs.gov/bbs).

Numbers of ravens and crows observed along 15 BBS routes in the San Francisco Bay area reveal distributional patterns similar to those described by the ACR road survey (Figure 5). Both survey sets indicate dramatic variation among routes (Table 1, Figure 3). Preliminary analyses indicate overall regional increases in both ravens and crows, but local trends vary

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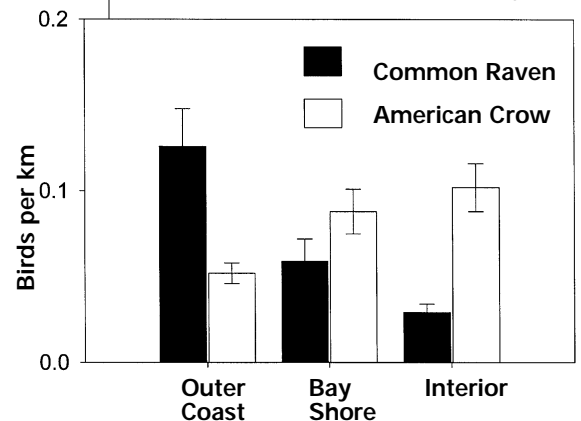


Figure 4. Mean number of Common Ravens and American Crows observed per km of survey route in outer coast, San Francisco Bay shore, and interior subregions in the San Francisco Bay area. Values for American Crow exclude Route 11 (see Figure 1). Error bars = standard errors.

◆ *Ravens and crows, continued*

greatly across the region, suggesting smaller-scale effects (Table 1). We are also examining long-term trends in winter abundances using Audubon Christmas Bird Count (CBC) data. Preliminary looks at several decades of CBC data reveal significant overall increases in both ravens and crows, with the strongest increases during the 1980s and 1990s.

We are evaluating regional breeding distributions by compiling breeding bird atlas (BBA) data from the San Francisco Bay area. BBAs are organized and developed separately by county, and they use standardized criteria to determine the likelihood of breeding for each bird species within 5-km blocks. The composite atlas reflects patterns that are consistent with BBS and ACR road surveys (Figure 6).

The growing numbers of ravens and crows is certainly no surprise, especially for species that benefit from agriculture, road kills, and garbage in human-altered landscapes. But patchy distributions and variable rates of change across the region suggest that explanations for their increasing numbers may not be so simple, and that associated increases in nest predation on other species may strongly depend on local conditions. Information from ACR's corvid road survey will help us to understand the implications of other ACR research—on raven home ranges, foraging behaviors, and nest predation at waterbird colonies. ■

This project received financial support from the Marin Community Foundation and the Marin and Sequoia chapters of the National Audubon Society.

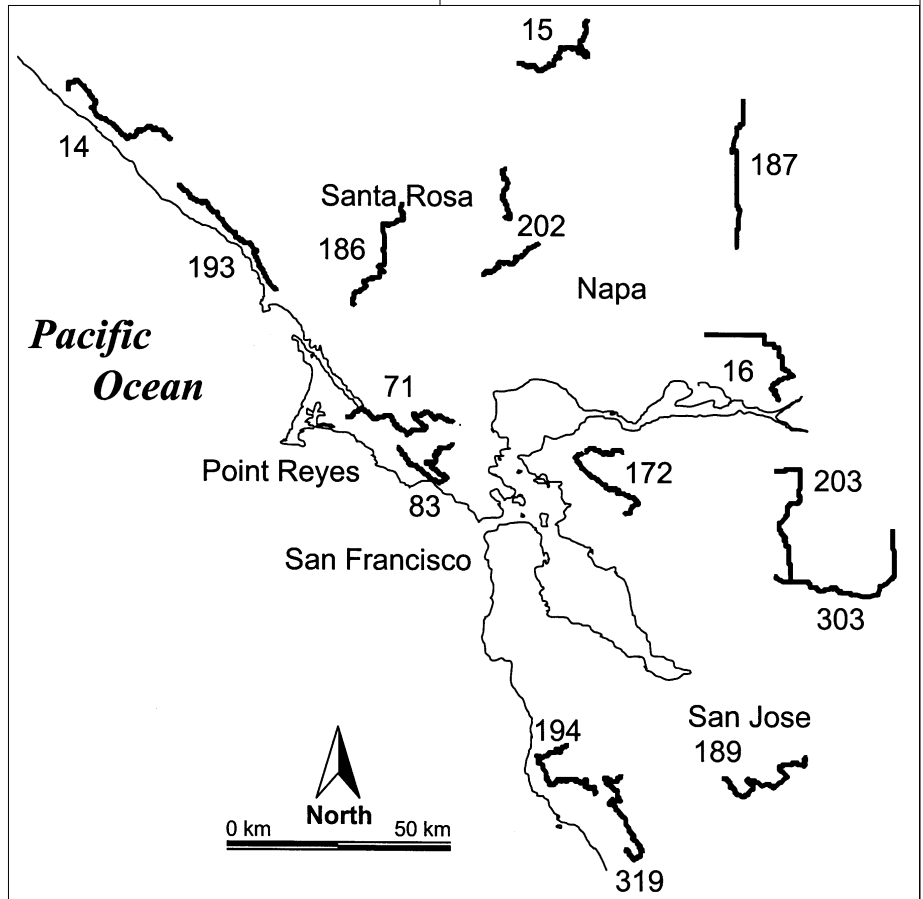


Figure 5. Breeding Bird Survey routes in the San Francisco Bay area. Labels are route identification numbers. See Table 1 for details on each route.

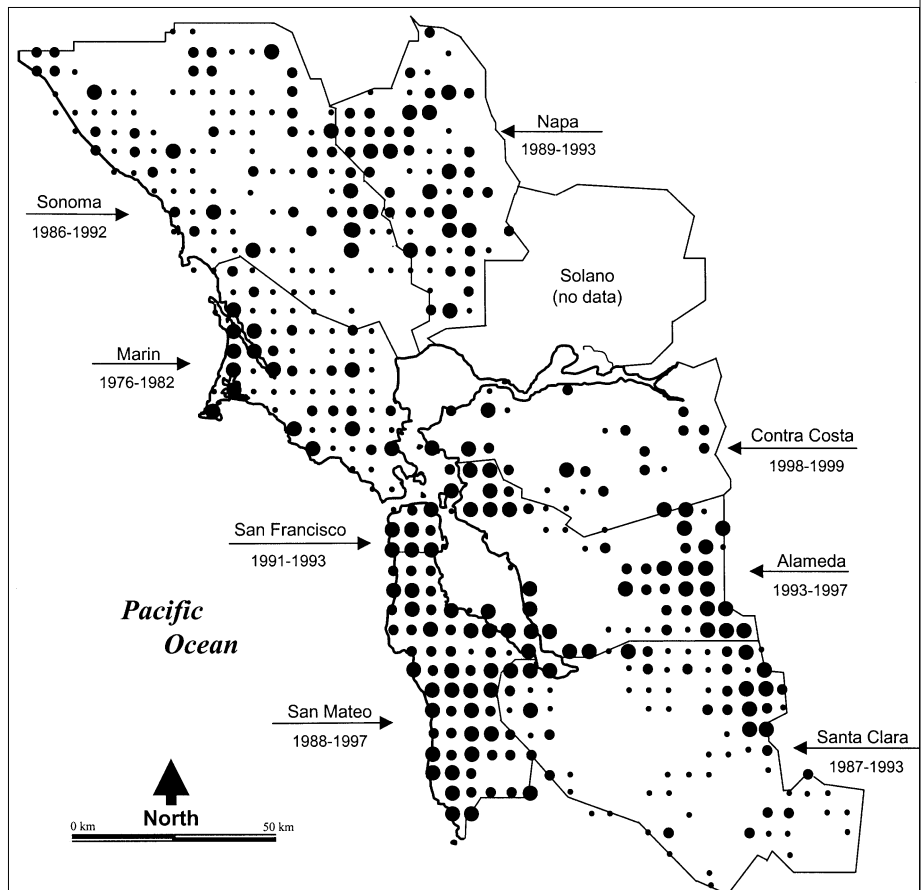


Figure 6. Composite breeding bird atlas for Common Raven in the San Francisco Bay area, compiled and mapped by Katie Etienne. Filled circles indicate likelihood of breeding in each 5-km block: **large circle**=confirmed; **medium circle**=probable; **small circle**=possible; **no circle**=no ravens observed. Field data were collected in the years indicated under each county name (Shuford 1993, Marin County Breeding Bird Atlas; Burrige 1995, Sonoma County Breeding Bird Atlas; R. Leong and B. Grummer, unpubl. Napa County; S. Glover, unpubl. Contra Costa County; B. Richmond, unpubl. Alameda County; Santa Clara Atlas Comm., unpubl. Santa Clara County; R. Johnson, unpubl. San Mateo County; M. Eaton, unpubl. San Francisco County).

The ecological history and role of fire in ACR management

Must We Have Fire?

by Greg deNevers

Fire is a topic sure to arouse passions from various points of view. People who have experienced the power and fury of a fire personally are especially prone to emotional responses. In this article I would like to explore the role fire plays in natural ecosystems, both in the presence and in the absence of people and our myriad interventions and manipulations, in the hope of stimulating a discussion of the various roles fire could play on the preserves managed by ACR.

Before people arrived in the New World, the only ignition sources were lightning, volcanoes, rock slides, and spontaneous combustion. The predominant source of ignitions was lightning. In coastal Central California, lightning fires may have recurred on 20- to 40-year cycles (Biswell 1989). Lightning is relatively rare in Central California compared with the Midwest or the Southeast, but lightning ignitions are recorded (Sugnet 1984). In his 25 years at ACR's Bolinas Lagoon Preserve (BLP), Skip Schwartz has seen one fire started by lightning. It occurred on the ridge south of Volunteer Canyon in the middle of the night and was quickly suppressed.

Fire return times of 20 to 40 years are short enough that most plant and many animal species were forced to adapt to this factor. Many of the species in our area exhibit multiple adaptations to the cyclically recurrent disturbance caused by fire. A classic example is the redwood. Redwoods have thick bark to protect the trunk from fire. Additionally, the small seeds of redwoods need flood, fire, or a landslide to remove duff in order to survive their first year of life. Fire is one of the primary ingredients in redwood reproduction by seed. Chaparral plants are characterized by the need for and the ability to survive intense fires. In the absence of fire, forest trees may replace chaparral. Recurrent fires can exclude invading trees and renew the chaparral.

Chaparral shrubs generally exhibit two strategies to survive fire. They may resprout from underground root masses, or they may respond to fire with abundant seed germination. The seeds of chaparral shrubs and annuals may lie dormant in the soil seed bank for decades, awaiting the signal from a fire to initiate growth. My personal favorite fire adaptation is that of the California newt, which exudes a viscous liquid from skin glands (Stromberg 1997). This liquid expands into bubbles of foam, which insulate the delicate amphibian and allow it to walk through a line of flames! These few examples indicate the broader pattern: that fire has been a natural component of California ecosystems for ages, and that the plants and animals living here have had to adapt to this intense selective pressure.

The human component

Native Americans were probably resident in villages in our area beginning about 4,000 years ago (Broughton 1994). They greatly increased the number of ignitions and the length of the fire season. A study of redwood tree rings on Bolinas Ridge indicates that during the last 500 years there was a fire somewhere on Bolinas Ridge every two to five years (Finney 1990). A similar study at Annadel State Park (Sonoma County) found a similarly short return time, and this was attributed to native burning (Finney & Martin 1992). We have a woe-

fully inadequate understanding of the breadth of reasons Native Americans burned vegetation. They may have been sophisticated in their understanding of fire and its multiple impacts. Their motivations may have been multiple and complex (Lewis 1973). A few of the reasons for native burning may have been: to open the forest understory for travel and hunting; to open lanes through chaparral (strip burning); to encourage the growth of plants suitable for food harvest; to protect villages from fire and/or enemies; to capture animals; to encourage the growth of plants to attract animals by providing food; or to improve habitat to increase the populations of favored prey species. Even with our limited understanding of the world view of Native Americans and their reasons for burning, it is clear that fire was one of the most powerful and favored tools available to them for altering the landscape in which they lived.

During the historic Euroamerican period in California (1861–present), there have been four major fires in the vicinity of BLP (Van Kirk 2001). These fires occurred in the years 1890, 1904, 1923, and 1945. They were probably much like the 1995 Vision Fire at Point Reyes (Point Reyes National Seashore 1995), with which many readers will be familiar. Each fire burned between 4,000 and 20,000 acres. All occurred during September or October, the driest time of year and the time we are most likely to get winds out

of the desert, known as Santa Ana Winds. Under these conditions, which are referred to technically as "fire-storm conditions," there is little or nothing people can do to control a fire. The Vision Fire is a good example. It burned relatively unimpeded until the winds reversed and cool, moist air from the ocean made the fire controllable. It is humbling, and criti-

Table 1. Fire frequencies for west Marin sites, calculated using mean fire intervals in years (\pm standard deviation) between all fire dates at each site for the period of analysis. Table recast from Brown et al. 1999.

Site	Period of analysis	Number of intervals	Mean fire interval	Range of intervals
Pine Gulch 1	1841-1906	8	8.1 \pm 2.7	4 to 12
Pine Gulch 2	1906-1945	3	13.0 \pm 4.6	8 to 17
Pine Gulch 3	1841-1945	11	9.5 \pm 3.8	4 to 17
Five Brooks	1820-1905	11	7.7 \pm 5.0	1 to 17
Limantour	1825-1918	11	8.5 \pm 5.5	3 to 18

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cally important, to recognize that there are conditions under which we cannot control, stop, or direct the course of a fire.

It is important to recognize that the main problem with fires occurs when they meet human developments. When fires destroy our buildings, it is a clear loss. When forests burn, it is generally a good thing. The negative prejudice about fires, based on the association with structures, often obscures our ability to make this critical distinction. The *Marin Journal* account of the 1890 fire would have the reader believe that "all of the timber" on the Wilkins and Bourne ranches, which later became BLP, was destroyed (Van Kirk 2001). But the *Marin Journal* account of the 1904 fire again refers to "giant oaks and redwoods" and "heavy woods" being destroyed (Van Kirk 2001). Surely 14 years is not long enough to regrow a "destroyed" forest! In the account of the 1890 fire, the *Marin Journal* reported "a fierce fire is raging in Bourne Canyon and we can see no way to prevent its going to his buildings." In fact it did not. In 1904, a group of men rushed over from Bolinas and "by their efforts alone the property was saved" (that is, the house). In the 1923 fire "Arthur Bourne's house was ignited by flying embers, but the fire was extinguished."

Fire suppression

Two years ago many of us watched in awe as flames approached one of our national icons, the nuclear laboratories at Los Alamos, New Mexico. The Los Alamos fire was, in part, a result of our national policy of fire suppression, the Smokey-the-Bear policy. This policy implicitly assumes that people can permanently exclude fire from fire-prone ecosystems. Actually, the only two likely scenarios are many small, frequent fires, or few large, infrequent fires. Complete prevention is impossible. One response in New Mexico has been to declare a state of fire emergency and to pass a law, which the governor has signed, that directs state and local authorities to enter National Forests and take "whatever measures they deem necessary" to reduce the threat of wildfire to local communities (New Mexico 2000). Apart from the federal authority/states rights issues, the New Mexico situation illustrates another nuance in our relationship with fire. Many Americans, especially in the West, want to live in fire-prone habitats, in flammable structures, with tinder fuels surrounding our buildings. This is an esthetically pleasing approach, until

the day of the fire. Private property owners may be insensitive to admonitions regarding the wisdom of this approach. Although California State law requires the removal of flammable vegetation around structures (Public Resource Code 4291), compliance with this measure is uneven and enforcement scant. One undesirable consequence of this situation is that public land managers may cut forest or chaparral on public lands to create fuel breaks to protect adjacent private property from fire.

A Forest Service study after the Los Alamos fire demonstrated that the fire burned most intensely in and around human communities, not in the surrounding National Forest (Forest Magazine 2000). Fuel loading is often not highest in the forest but rather in towns, where horticultural plantings magnify the fuel load. In any case, a forest with low or high fuel loads would carry a fire to town. Yet the New Mexico Legislature looks to surrounding public lands for protection from fire. The policy of creating fuel breaks on public lands to protect neighboring private lands is followed by the Marin Municipal Water District and the Marin County Open Space District (Charles 1993). The fuel break on Panoramic Highway near the Mountain Home Inn (above BLP) provides a clear example. Here a 200-foot wide fuel break has been created by removing all woody vegetation on public land, in the hope of preventing a fire in the Redwood Creek drainage from reaching private homes along Panoramic Highway. The practicality of creating fuel breaks is currently being questioned. The eight-lane, asphalt fuel break in Oakland that we call Highway 24 was jumped by fire brands multiple times during the 1989 Oakland Hills fire. The growing conventional wisdom seems to be that protecting structures through fire-safe construction (non-flammable roofs and siding) is more effective than creating fuel breaks.

The answer to the question rhetorically posed in the title of this article is "yes." We must have fire in natural lands. The ACR scientific staff is currently preparing a fire management plan for all three preserves. The plan intends to be forward looking and proactive in its approach to fire management. We hope to incorporate the use of controlled fire into the tool kit we use to manage our preserves. We also intend to prepare as much as possible for wildfire events we cannot control, so that the preserves will not be negatively impacted. ■

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In progress: project updates

North Bay counties heron and egret project ▶ We are completing the 11th year of tracking nesting activities in heron and egret colonies across five Bay Area counties. The data are used to examine regional patterns of reproductive performance, disturbance, habitat use, and spatial relationships among heronries.

Cape ivy control ▶ Len Blumin continues to remove nonnative cape ivy from the riparian vegetation in ACR's Volunteer Canyon. The use of goats to consume the invasive weed was unsuccessful in clearing out small stems and sprouts in the leaf litter. However, hand weeding has been very successful. With most of the work completed along the creek above the buildings, Len and others are now focused on restoring the alder grove at the bottom of the Canyon. Continued vigilance in weeded areas has been important, to combat resprouts of black nightshade, *Vinca*, and Japanese hedge parsely.

Common Raven study ▶ ACR biologists, along with colleagues at the Point Reyes Bird Observatory, are radio-tracking nesting ravens in Marin County and observing raven predatory behaviors at heron and egret nesting colonies. We also attempted to establish conditioned taste aversion at ACR's Picher Canyon heronry, to reduce raven predation on egret nestlings, but it is soon to know if the behaviors of the resident ravens have been altered. ACR's regional road survey in the San Francisco Bay area revealed concentrations of ravens in some urban/suburban areas and along the outer coast.

Livermore Marsh ▶ As ACR's Livermore Marsh transforms from a freshwater system into a tidal salt marsh, Katie Etienne, Rachel Kamman, and Lauren Hammack are studying the relationship between increasing tidal prism and marsh channel topography. Ellen Blustein is monitoring changes in bird use. These data will be combined with measurements of vegetation change to reveal fundamental patterns that characterize developing tidal marshes, and will contribute to future restoration designs.

Newt population study ▶ Thirteen years of newt surveys have been conducted along the Stuart Creek trail at ACR's Bouverie Preserve. The results track annual and intraseasonal abundance and size/age and spatial distributions along the creek. Last year, 61 days of observation yielded a count of 2,246 newts, of which 96% were red-bellied newts and 4% were California or rough-skinned newts.

Vernal swales ▶ Rebecca Anderson-Jones is developing an ecological inventory and assessment of vernal swales in the seasonal wetlands of the lower grassland at Bouverie Preserve.

Shorebirds ▶ ACR field observers completed the 12th year of shorebird censuses on Tomales Bay. Six baywide counts are conducted annually. Based on these data, John Kelly is investigating local habitat values and winter population patterns of shorebirds. He is also studying the effects of winter storms on energy balance and habitat use by Dunlins.

Tomales Bay plant species database ▶ Grant Fletcher is tracking populations of *Castilleja ambigua* ssp. *humboldtiensis* and *Cordylanthus maritimus* ssp. *palustris*, rare salt marsh annuals at Tomales Bay and in Mendocino County.

Tomales Bay waterbirds ▶ Since 1989-90, teams of field observers have conducted winter waterbird censuses from survey boats on Tomales Bay. The results provide information on habitat values and conservation needs of 51 species, totaling up to 25,000 birds.

Sudden oak death ▶ Rebecca Anderson-Jones is tracking the threat of the "fungal" pathogen *Phytophthora* (a watermold, Oomycota) associated with Sudden Oak Death (SOD), which may occur at Bouverie Preserve. SOD can kill coast live oaks, black oaks, and tan oaks. We expect to be included in a regional mapping project by investigators at Sonoma State University and U.C. Berkeley, which will use high-resolution aerial photography and ground truthing to track the progress of SOD.

Visiting investigators at ACR

Yvonne Chan and Peter Arcese (Univ. Wisconsin), *Subspecific differentiation and genetic population structure of song sparrows in the San Francisco Bay area.*

Jeff Corbin and Carla D'Antonio (UC Berkeley), *Effects of invasive species on nitrogen retention in coastal prairie.*

Christopher DiVittorio (UC Berkeley), *Dispersal and disturbance colonization in a California coastal grassland.*

Peggy Fong (UCLA), *Algal indicators of nutrient enrichment in estuaries.*

Brenda Grewell (UC Davis), *Species diversity, rare plant persistence, and parasitism in mid-Pacific Coast salt marshes.*

Jodi Hilty (UC Berkeley), *Carnivore use of riparian corridors in vineyards.*

Martha Hoopes and Cheryl Briggs (UC Davis), *Effects of dispersal on insect population dynamics and parasitoid diversity in galls of *Rhopalomyia californica* on *Baccharis pilularis*.*

Gretchen LeBuhn (CSU San Francisco), *The effect of landscape changes on native bee fauna and pollination of native plants in Napa and Sonoma counties*

Jacqueline Levy (CSU San Francisco), *The impact of butterfly gardens on pipevine swallowtail populations.*

Steven Morgan, Susan Anderson, and others (UC Bodega Marine Lab), *Western Center for Estuarine Ecosystem Indicator Research (ecological indicators in West Coast estuaries).*

Jennifer Shulzitski (USGS Golden Gate Field Station), *Multi-scaled vegetation data to predict wildlife species distributions using a Wildlife Habitat Relationship model.*

Bibit Traut (UC Davis), *Structure and function of coastal high salt marsh ecotone.* ■



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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Vernal pool at Bouverie Preserve [see page 1](#)



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