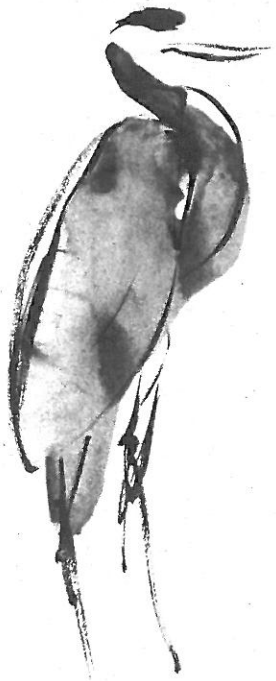


THE ARDEID

Research and Resource Management at Audubon Canyon Ranch

Spring 1999

Shorebirds on Tomales Bay

Subtle Preferences

by John P. Kelly

Ten years of monitoring by local field observers results in an intimate view of an estuary's life in winter.

At the forceful *yew-yew-yew* of a Greater Yellowlegs, every individual Western Sandpiper and Dunlin—about 600 foraging on the flats immediately in front of me—suddenly froze, silent and alert, many heads tilted skyward. For a nearly imperceptible instant, all activity stopped. Their responses were so synchronous and so brief that I had the impression of watching a shorebird movie skip a frame or two without clearly interrupting the birds' normal walking and probing in the soft mud. The message was clear: shorebirds must balance the competing values of efficient foraging and continuous vigilance.

Naturally, foraging opportunities and predation pressures change, and such changes alter the survival values of habitat areas for shorebirds. These dynamics are reflected in the landscape as shifting abundances of wintering shorebirds. This year, field observers at Audubon Canyon Ranch completed the tenth year of monitoring shorebirds on Tomales Bay (see sidebar *TRENDS*, page 2). In general, shorebird use of Tomales Bay is polarized, with the greatest densities and abundances occurring at opposite ends of the Bay, on large tide flats at the mouths of Walker and Lagunitas creeks (Figure 1). However, the subtle values of other habitat areas may be crucial to the health of wintering shorebirds on Tomales Bay.

When winter tides rise to about four feet, undulating sheets of small sandpipers race across the open water toward high-tide roosting sites. At this time shorebird flocks can be seen sweeping by fishing boats and over kayaks in the middle of the bay, stretching, turning, and flashing silver-dark-silver, until in a flash they disappear in the distance. A central question in evaluating the importance of alternative habitat areas is whether birds move freely among the different sites. Several years ago, ACR field observers conducted some all-day watches at key points in the Bay. The results suggested that shorebirds move freely between foraging and roosting sites within each of the north and south Tomales Bay areas, but that very little movement occurs in the mid-bay section between Cypress Point and Walker Creek.

This year, a banding experiment confirmed that discrete groups of shorebirds use the north and south ends of the Bay. In a reciprocal translocation of color-banded Dunlin between the mouths of Walker and Lagunitas creeks, all 18 resighted birds had returned to their sites of capture. These results reveal strong winter site fidelity and fairly distinct northern and southern Tomales Bay populations. It is likely that other shorebird species exhibit similar behaviors. The presence of two wintering areas in the Bay, rather than one, has important implications for conservation: each foraging site is relatively more important because wintering populations have fewer habitat alternatives.

Sometimes, as the tide is rising, shorebird flocks gradually surround me. Standing with my telescope on the flats, I can watch individuals from "within the flock," with birds foraging five or six feet away in any direction. From such a perspective, loud and ubiquitous "peeping" is a strik-

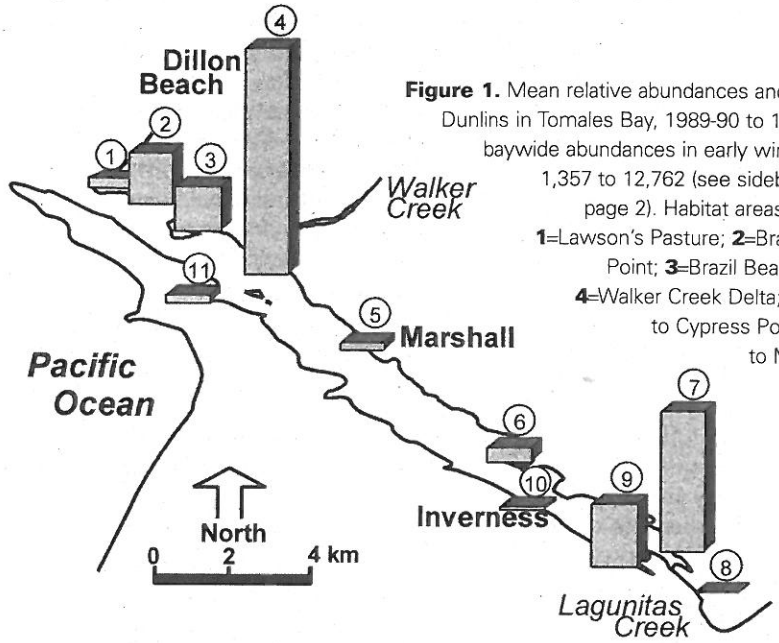


Figure 1. Mean relative abundances and distribution of Dunlins in Tomales Bay, 1989-90 to 1998-99. Annual baywide abundances in early winter range from 1,357 to 12,762 (see sidebar *TRENDS* on page 2). Habitat areas illustrated are: **1**=Lawson's Pasture; **2**=Brazil Beach/Sand Point; **3**=Brazil Beach/Tom's Point; **4**=Walker Creek Delta; **5**=Nick's Cove to Cypress Point; **6**=Marshall to Millerton Gulch; **7**=Bivalve; **8**=Giacomini Pasture; **9**=Willow Point; **10**=Inverness; **11**=White Gulch.

The ink painting used in *Ardeid*'s masthead is the original work of Claudia Chapline, Stinson Beach artist and gallery-owner and friend of ACR. Special thanks to her for this contribution.

Shorebirds, continued

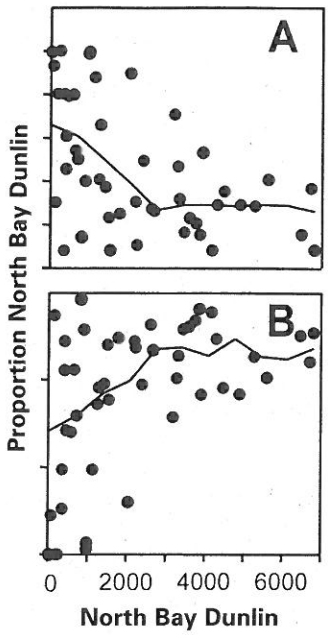


Figure 2. Proportional decreases in shorebird use with increased population size suggest a "buffer effect" that could indicate preferred habitat (see text). However, shorebird use of foraging sites on Tomales Bay is probably driven by density-independent effects of rainfall and runoff. During periods of heavy rainfall, local populations decline, and habitat preferences shift from Walker Creek Delta (**B**) to alternative feeding habitat at Brazil Beach (**A**). Trend lines = running median.

ing feature of these aggregations, revealing, presumably, a swarm of defensive announcements from a confusion of individual foraging spaces. At this close range, the drive to forage efficiently is impressive. When the flock moves off, it becomes a very different thing: the familiar but silent peppering of the shore by distant sandpipers.

The number of birds that can profitably share a feeding area is a fundamental question in ecology and conservation. In general, shorebirds begin to occupy less-preferred habitat when preferred foraging sites become too crowded. Subsequently, habitat selection becomes "density dependent." Thus, preferred sites can be detected by a "buffer effect" indicated by a decreasing proportion of the population as the number of wintering birds increases (Figure 2). Conversely, the proportional use of less-preferred habitat should increase with the overall population. Because population size can vary greatly among years, the value of alternative foraging sites may fluctuate dramatically.

Ten years of shorebird monitoring on Tomales Bay reveals changes in the proportional use of habitat areas, but the appearance of a "buffer effect" may be misleading (Figure 2). Density-independent factors, such as wind exposure, rainfall, and freshwater runoff can cause the relative profitability of foraging areas to shift—regardless of the number of birds. On Tomales Bay, rainfall accounts for significant shifts in shorebird use that suggest a preference for less-frequented habitat at Brazil Beach and along the east shore during rainfall periods (Figure 3). Such seldom-preferred areas could represent crucial refugia that allow local populations to persist during harsh winter conditions.

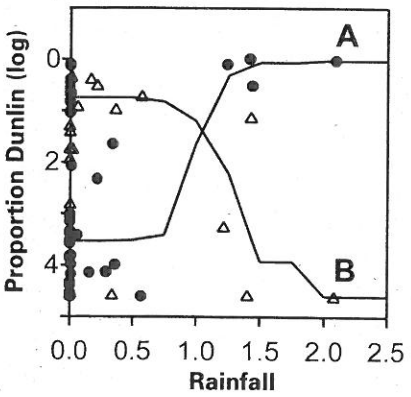


Figure 3. Rainfall effects dominate shifts in proportional habitat use by shorebirds on Tomales Bay. On days with more than an inch of rainfall, more Dunlins occur at Brazil Beach (solid circles; **A**=running median) and along the east shore south of Marshall (not illustrated), while proportionally fewer Dunlins occur at the mouth of Walker Creek (open triangles; **B**=running median) and the mouth of Lagunitas Creek (not illustrated).

Midwinter Crunch

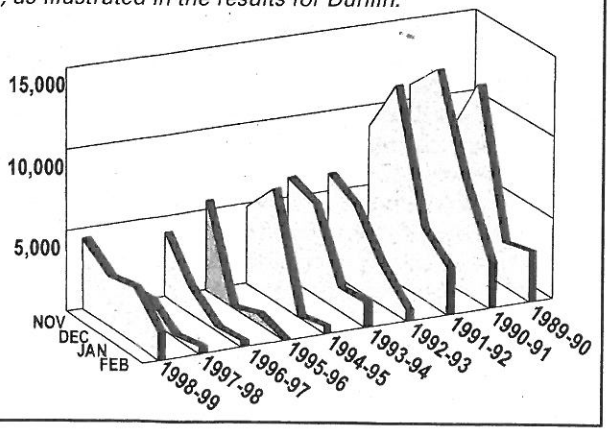
On calm, warm winter days, active foraging flocks often include individuals that stop to nap with bill tucked under a wing, to preen, or to just stand around in the crowd. This is not surprising, considering that in other studies I have found that shorebirds regulate their weight during winter. After winter solstice and before premigratory fattening in late March, Dunlins generally reduce their weight slightly in mild weather, and increase energy reserves slightly when it rains. Storing more fat in the rain makes sense because heavy storms could force shorebirds to fast. But why do they lose weight on mild winter days? They are clearly able to store more fat, but they do not. The best answer may be that fat storage carries a cost in reduced quickness and agility needed to avoid predation by raptors. By minimizing risk of predation, however, starvation risk remains real.

While rainfall may cause shorebirds to increase their food intake, it can also degrade the suitability of foraging sites. During extended periods of rainfall, Least and Western sandpipers huddle along the edges of pickleweed or Spartina, or form beaded strings along tide channels high into the saltmarsh, waiting for the tide to drop. At such times, uncertainty must challenge their patience because runoff filling the Bay can greatly reduce, or even prevent, tidal exposure of feeding areas. If birds cannot obtain enough food to com-

T·R·E·N·D·S

A dedicated team of ACR field observers have developed an exemplary program to track the health of shorebird populations in Tomales Bay. For many, counting shorebirds has become an ongoing routine that provides personal interaction with this amazing estuary. After ten years of monitoring, baywide totals suggest several general patterns, as illustrated in the results for Dunlin.

- *Winter populations vary dramatically among years. Thus, the carrying capacity of Tomales Bay is either highly variable, or rarely met.*
- *Peak abundances occur in mid-November.*
- *Midwinter declines occur every year and are steeper in wet winters.*
- *Annual and intraseasonal differences in population size are strongly related to rainfall.*
- *Large winter populations during the early 1990s suggest cumulative effects of successive years of drought, while declining populations in the mid-1990s suggest cumulative effects of successive wet winters. These speculations require further investigation.*
- *El Niño conditions in 1997–98 resulted in extremely low numbers of Dunlins and other shorebirds, whereas drier La Niña conditions in early to midwinter 1998–99 revealed a substantial recovery.*



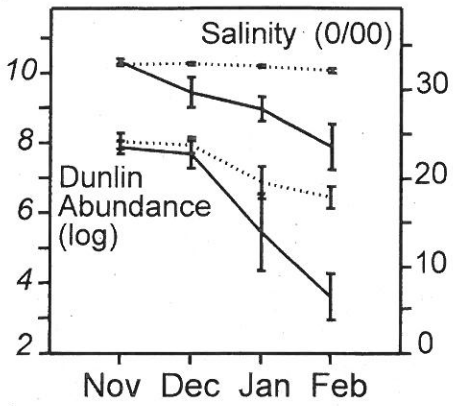


Figure 4. Intraseasonal declines in mean Dunlin abundance reflect underlying changes in salinity. Trend lines are steeper for southern (solid) than for northern (dotted) Tomales Bay (error bars = standard error).

pensate for their energy needs, they may be forced to either leave the area or starve.

In estuaries like Tomales Bay, episodes of high stormwater runoff interact with long water residence times (slow exchange between bay and coastal waters) to create periods of substantially reduced salinity. Such low salinities can kill marine invertebrate prey, or cause them to recede deeper into the mud. The impacts of reduced salinity on the suitability of foraging sites may account for at least some of the rainfall effects on shorebird distributions in Tomales Bay. At the south end of the Bay, salinity generally declines in late winter relative to the north end of the Bay, and this pattern is reflected in reduced levels of shorebird use (Figure 4).

Where do shorebirds go when feeding areas in southern Tomales Bay are degraded by runoff? I don't know. Shorebird use of alternative habitats not adjacent to Tomales Bay has not been studied. Whether some south-Bay shorebirds move to the north end of the Bay during late winter is also unknown, but abundance patterns indicate general midwinter departures. Nils Warnock and others at the Point Reyes Bird Observatory (1995, Wilson Bulletin 107:131-139) recently found that at least some Dunlins move from Bolinas Lagoon in midwinter to seasonally available wetlands in the Sacramento Valley. Such movement could be driven by the adaptive exploitation of seasonally available inland habitats. However, steeper midwinter declines in southern than in northern Tomales Bay suggest that deteriorating local conditions account, at least in part, for midwinter reductions of shorebird use of coastal sites.

To watchers of estuaries, brief absences of wintering shorebirds arouse an eerie sense of emptiness, linked to questions about wind exposure, flooding, falcons, water quality, or human disturbance. To further complicate the matter, annual fluctuations in shorebird numbers may reflect remote processes that affect productivity in arctic breeding areas, or possibly, large-scale oceanographic processes that influence recruitment and growth of prey populations. For even the most serious observers, describing the habitat values of coastal wetlands is no simple task.

At least one principle relevant to this challenge is evident from ACR's work on Tomales Bay: dominant patterns of habitat use should not be taken as evidence of lessened dependence on any particular area. Rather, the persistence of winter shorebird populations may depend on dynamic preferences within a landscape of alternative sites. ●

John Kelly directs ACR's Research and Resource Management Program from his preferred habitat on Tomales Bay.

◗ In Progress (see also back page)

Coastal prairie ◗ To allow for an assessment of the ecosystem effects of grassland restoration, we have discontinued seasonal control (mowing) of non-native annual grasses in a grassland restoration area at Cypress Grove Preserve. Looming problems of invasive nonnative perennial grasses, such as velvet grass (*Holcus lanatus*), may swamp concerns about nonnative annuals in coastal grasslands, and will require new approaches to grassland restoration and management.

The Watch

The following list includes ACR field observers and habitat restoration volunteers since the previous *Ardeid*. Please call (415) 663-8203 if your name should have been included.

PROJECT CLASSIFICATIONS:
C = Common Raven Study
D = Harbor Seal Study
H = Heron/Egret Project
I = Plant Species Inventories
M= Marsh Monitoring Project
N = Newt Survey
R = Habitat Restoration
S = Tomales Bay Shorebird Project
W = Tomales Bay Waterbird Census

Dan Abraham (R); Kristen Dowd-Addicks (HW); Kathy Allen (R); Sarah Allen (CS); Bob Baez (SW); Norah & Hugh Bain (SH); Tom Baty (W); Louise Beilfelt (N); Charles Benedict (CH); Gordon Bennett (S); Gay Bishop (S); Meredith Bleier (R); Roxanne Bleier (R); Alistair Bleifuss (H); Noelle Bon (N); Len Blumin (RN); Patti Blumin (RH); Ellen Blustein (HMSW); Janet Bosshard (H); Maureen Bourbin (H); Tom Bradner (R); Joan Breece (R); Susan Buckner (C); Liz Burroughs (W); Ken Burton (SW); Barbara Carlson (N); Bill Carlson (N); Anne Cassidy (H); Ted Chandik (C); Zoe Chandik (C); Georgia Connon (R); Richard Crapuchettes (H); Rigdon Currie (CHS); Dawn Davis (N); Lori Dervin (H); Jim Devore (H); Nancy De Stefanis (C); Joe Di Salvo (C); Carolyn Dixon (H); Roberta Downey (R); Dick Downing (H); Jenny Downing (H); Joan Dranginis (H); Joe Drennan (W); Lew Edmondson (HS); Marilyn Edmondson (HS); Ted Elliot (H); Bob Evans (H); Jules Evens (S); Sheryl Fairchild (H); Katie Fehring (HSW); Betty Fehring (H); Ken Fehring (H); David Ferrera (W); Margaret Finnigan (R); Binny Fischer (CHW); Grant Fletcher (RHISW); Virginia Fletcher (S); Leslie Flint (RC); Jim Fox (H); Ken Fox (RW); Carol Fraker (H); Dan Froehlich (SW); Harry Fuller (CW); Kate Fuller (C); Tom Gardali (C); Sam Gilbert (W); Tony Gilbert (SW); Garth Gilchrist (HW); Della Gilmore (N); Keith Gish (C); Ellen Goldstone (N); Pat Gordon (C); Phil Gordon (C); Irene Grauten (R); Margaret Greene (H); Philip Greene (H); Leslie Grella (S); Madelon Halpern (H); David Hastings (W); Diane Hichwa (H); Edna Hickok (H); Terry Horrigan (S); Darren Howe (D); Ann Hudgins (R); Jeri Jacobsen (H); Conrad Jones (CH); Juniper Club (N); Gail Kabat (W); Lynnette Kahn (HS); Greg Kamman (M); Rachel Kamman (M); Don Kimbel (HW); Mary Ellen King (DW); Marion Kirby (N); Brian Kirven (HW); Jim Knight (H); Carol Kuelper (S); Chris Lantman (D); Jim Larkin (D); Linda Lebovics (H); Alexis Lee (H); Laura Leek (W); Robin Leong (H); Michele Liapes (W); Eileen Libby (CH); Mike Lighthiser (M); Joan Lynn (H); Flora Maclise (CMH); Jo Maillard (CH); Michael Manner (H); Alan Margolis); M.D. (R); Roger Marlowe (W); Chris McAuliffe (H); Harmony Mercedes (R); Byron Meuchel (R); Leslie Meuchel (R); Jean Miller (CHR); Dan Murphy (CW); Joan Murphy (C); Karen Nagle (H); Wally Neville (H); Terry Nordbye (HSW); Richard Panzer (H); Patagonia employees (R); Ray Paula (CH); Karen Paull (DW); Zorya Payzant (H); Tony Paz (R); Gian-Marco Pizzo (M); Myrlee Potosnak (H); Grace Pratt (H); Helen Pratt (H); Mary Przyblyski (N); Matt Reese (D); Jeff Reichel (H); Linda Reichel (CH); Rudi Richardson (CW); Arnold Roessler (H); Jamie Ross (HW); Jared Roth (C); Ellen Sabine (CHS); Diane Samples (N); Danielle Saunders (CH); Don Sanders (CH); Marilyn Sanders (CHR); Fran Scarlett (H); Dave Schurr (SW); Anne Sclare (H); Craig Scott (DSW); Kevin W. Shaw (D); Ann Smith (H); Duane Smith (H); Joseph H. Smith (HRW); Robin Smith (C); Karen Sommer (R); Anne Spencer (S); Paul Spitzer (W); Sue Spoffard (CH); Rich Stallcup (CSW); Jean Starkweather (H); Stinson Beach 3rd graders (R); Christina Sunley (H); Sarah Tappen (RW); Judy Temko (HS); Paula Terry (H); Janet Thiessen (HSW); Gil Thomson (H); Tanis Walters (S); Ralph Webb (H); Rosalee Webb (H); Adeline Whitmore (H); Diane Williams (S); Bill Wilson (HW); Ken Wilson (H); David Wimpfheimer (SW).

Managing pest plants on ACR properties

Out of Place

by Rebecca Anderson-Jones

"Like a shadow, Holcus *sweeps across the prairie, leaving the landscape simplified and homogenous. Grassland "mosaics" disappear. Just a few years ago, most of the Cypress Grove Preserve hillside south of Livermore Marsh was dominated by a mix of nonnative annual grasses, but now it is covered with* Holcus *in nearly all areas lacking hemlock. The ability of this species to invade and persist in native grass areas, as we are seeing north of the marsh, has also been well-documented along the Mendocino coast."*

With these words, John Kelly, ACR's Director of Research and Resource Management, recently described the devastating impact of a nonnative perennial grass invasion. This sobering image is a small hint at the enormous nonnative species invasion problem in California and across the globe. Our response to the problem is necessarily complex, and involves identifying pest species; prioritizing control efforts in the context of ACR's goals and resources; developing, testing and implementing control methods; and funding associated personnel and equipment costs. These challenging tasks are complicated by the lack of published research on the invasion biology of many—if not most—problem species and a similar paucity of research on the restoration ecology of particular ecosystems. Nevertheless, we cannot freeze time to conduct such research before making critical management decisions. Invasive species continue to arrive, persisting and reproducing at alarming rates, changing both the face of the land, and its ecological character. While invasive pest species fall into many taxonomic categories, plant invaders are among the most prolific, subtle and insidious. Weed control has never been so important at ACR.

What makes invasive plant control so important? Part of the answer hinges on the characteristics that make a plant a potential invader. In *Assessment and Management of Plant Invaders*, Sarah Reichard of the University of Washington, Seattle, identifies the following characteristics of invasive potential (Luken and Theiret 1997): (1) the ability to thrive across a wide latitudinal range, (2) a history of invasive growth elsewhere, (3) the capacity for vegetative as well as sexual reproduction, (4) a short juvenile period, (5) a long fruiting period, and (6) extended seed longevity. At ACR, our efforts to manage invasive plants are rooted in the recognition that these characteristics allow invasive nonnative plants to alter ecosystem structure and function in significant ways. While endemic plants evolve within ecological parameters that provide a physical and biological context for their growth and development, introduced species arrive in environments that often lack the coevolved predators and parasites or the abiotic variables necessary to keep their growth in check. Invasive introduced species bring with them the potential for dramatic ecological changes in such areas as primary productivity, habitat structure, nutrient dynamics, soil moisture content, local hydrology, community dynamics and disturbance patterns. Changes in any of these parameters may lead to other cascading ecological effects, with the resulting species composition far different from, and potentially less diverse than, the pre-invasion assemblages.

Table 1. A partial list of key pest plants on and immediately adjacent to ACR properties. Invasive potential is ranked according to the California Exotic Pest Plants Council's (CalEPPC) "Exotic Pest Plants of Greatest Ecological Concern in California" (1996). **A-1** = widespread, aggressively displace native plants and natural habitats; **B** = wildland pest plants of lesser invasiveness. ACR properties affected include: **BLP** = Bolinas Lagoon Preserve; **TB** = Cypress Grove Preserve and other Tomales Bay Properties; **BP** = Bouverie Preserve.

KEY PLANT SPECIES OF CONCERN TO ACR

Scientific (common names)	Family	ACR Properties	Invasive Potential
Delairia odorata (cape ivy)	Asteraceae	BLP	A-1
Rubus discolor (Himalayan blackberry)	Rosaceae	BP	A-1
Centuarea solstitialis (yellow star thistle)	Asteraceae	BP	A-1
Genista monspessulana (French broom)	Fabaceae	BLP, TB, BP	A-1
Ulex europaeus (gorse)	Fabaceae	TB	A-1
Carpobrotus edulis (iceplant)	Aizoaceae	TB	A-1
Carduus pycnocephalus (Italian thistle)	Asteraceae	BLP, TB, BP	B
Conium maculatum (poison hemlock)	Apiaceae	BLP, TB, BP	B
Phalaris aquatica (harding grass)	Poaceae	BLP, TB, BP	B
Festuca arundinaceae (tall fescue)	Poaceae	BLP, TB	Very high*

*Not ranked by CalEPPC

Thorny Problems

At ACR's Bouverie Preserve, two highly invasive species provide challenges in pest plant management. Along the Stuart Creek riparian corridor, Himalayan blackberry (*Rubus discolor*), displaces the native California blackberry (*R. ursinus*), ferns, and other indigenous riparian flora. This non-native berry grows quickly to form tall, dense hummocks that block access to the light needed by native plants attempting to grow among the canes. In dry clearings within the mixed evergreen forest and among the grasslands and oak woodlands, small patches of yellow star thistle (*Centuarea solstitialis*) have become established and are spreading through the understory. Both Himalayan blackberry and star thistle are heavily armed at maturity, reproduce readily, and require vigilant long-term eradication strategies.

Yellow star thistle provides a good illustration of the impact nonnative plant invasions can have on ecosystem dynamics. Research conducted by Dr. Kevin Rice, of the University of California at Davis' Department of Agronomy and Range Science, demonstrates a link between introduced annual grasses and yellow star thistle invasions (pers. com.). In most of the grasslands and oak woodlands in California, introduced annual grasses long ago won the competitive battle for

KEEPING THE WEEDS OUT

While we focus on control and eradication of invasive nonnative species, we also recognize the importance of limiting the introduction of new pests onto our properties. Anyone who spends time on an ACR preserve is a potential carrier of propagules with the potential for introducing invasive species. The trails and waterways that attract visitors can serve as corridors for introducing and distributing weedy plants. By taking time to clean maintenance vehicles regularly and being mindful of the seed-carrying capacity of hiking boots and other field equipment, we can help limit unintended plant dispersal and minimize our role in introducing new pests. Communicating these cautions to our visitors is one step in fulfilling our mission to "educate children and adults about the natural world and the need to protect it," but are such cautions adequate to limit or control the introduction of nonnative species? A crucial lesson in the conservation of natural areas is that ongoing restoration activities are needed to meet the challenge of preserving our ecological heritage.

light over native perennial bunch grasses. Star thistle is favored by the changes in soil moisture that occur as a direct result of shallow-rooted annual grasses supplanting deep-rooted, native perennials. Early in the growing season, star thistle develops long taproots that give it access to the deep soil water that will sustain it into the dry summer. Ultimately, star thistle dries the soil water to a depth unequaled by grasses, tipping the competitive scales further in its favor. Star thistle also produces abundant, easily distributed seeds with a very high viability rate. These hydrological and reproductive strategies have contributed to this plant's wide distribution. In the nearly 150 years since yellow star thistle was introduced to California in alfalfa hay, it has invaded approximately 20 million acres in the state. Ultimately, we hope to eliminate this noxious weed on ACR properties. Our chances of success are strengthened by the efforts Kevin Rice and others have made to understand the biology of this problem plant.

Cape Ivy Control

At ACR's Bolinas Lagoon Preserve, we are concerned about the rampant growth of cape ivy (*Delairia odorata*) in Volunteer Canyon. Also known as "the kudzu of the west," cape ivy originated in South Africa. Introduced to the United States approximately 100 years ago, this tenacious vine reproduces vegetatively and is capable of resprouting from any piece that contains a single node. It averages one centimeter of growth per day year-round. Managed as a problem plant in the neighboring Golden Gate National Recreation Area, this highly competitive vine has demonstrated the capacity to reduce species richness significantly. In Volunteer Canyon, its dominance over native vegetation has been astonishing. Until recent eradication efforts began to reverse the trend, little native herbaceous vegetation could be seen where cape ivy was well established, and few ferns were visible on the trail once named for them. Instead, cape ivy 's prolific growth carpeted the valley floor, growing over shrubs, snags and downed wood to blur the edges between vertical strata while forming a nearly monocultural understory. While manual removal of cape ivy is challenging, the effort in Volunteer Canyon shows promise under Len Blumin's leadership.

On 3 February 1999, President Clinton acknowledged the scope of the invasive species problem by enacting an Executive Order "to prevent the introduction of invasive species and provide for their control and to minimize the economic, ecological, and human health impacts that invasive species cause." At Audubon Canyon Ranch we know that fiercely competitive nonnative plants threaten not only the land holdings we protect, but also the ecosystems and landscapes to which our properties belong. The contest between invasive pest plants and land managers extends well beyond our boundaries, and we have many allies in the struggle. Nearly every land management agency and NGO in the state is responding to the growing crisis posed by invasive species. Organizations ranging from the Bureau of Land Management, to the San Francisco League of Urban Gardeners are working together to share information and develop strategies for a task we recognize as both difficult and vital.

Anyone who has been confronted with the all too successful competitive fitness of cape ivy, yellow star thistle, or velvet grass (*Holcus lanatus*) knows what it is to be haunted by the specter of biological simplification referred to in John Kelly's comments above. Biodiversity is the ultimate loser when invasive plants grow and spread unchecked. ACR's mission includes the commitment to "preserve, protect and manage" our properties as "sanctuaries for native plants and animals." This means stewardship and unrelenting battle against the likes of cape ivy, Himalayan blackberry, yellow star thistle and velvet grass, among others (see Table). ●

Rebecca Anderson-Jones is ACR's Education Specialist and Bouverie Preserve Biologist, is currently directing the control of Himalayan blackberry and investigating the value of vernal swales at Bouverie.

In Progress (see also back page)

Grazing ◗ Rebecca Anderson-Jones is reviewing how grazing functions as a management tool at Bouverie Preserve. While mid-spring grazing interferes with Red-winged Blackbird nesting, later in the season cattle preferentially graze new oak growth and moist vernal pool plants rather than the drier introduced grasses we intend to control. A winter grazing schedule coupled with more intensive herd management may be enough to tip the competitive edge toward greater native biodiversity here. We hope to begin this schedule in December.

THE ARDEID

Research and Resource Management at Audubon Canyon Ranch

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

The Ardeid is published twice yearly by Audubon Canyon Ranch as an offering to field observers, volunteers, and supporters of ACR Research and Resource Management. To receive *The Ardeid*, please call or write to the Cypress Grove Research Center. Subscriptions are available free of charge; however, contributions are gratefully accepted.

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AUDUBON CANYON RANCH IS A SYSTEM OF WILDLIFE SANCTUARIES AND CENTERS FOR NATURE EDUCATION

BOLINAS LAGOON PRESERVE • CYPRESS GROVE PRESERVE • BOUVERIE PRESERVE

Livermore Marsh: rearranged by natural processes

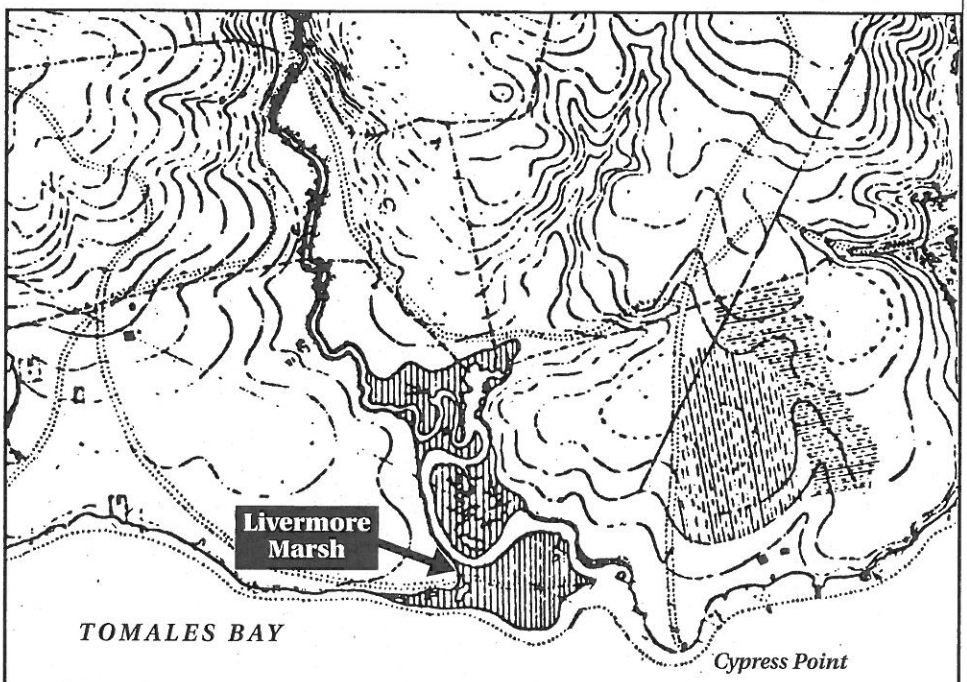
Changing Perspectives

by Katie Etienne

When your gaze sweeps across the sculpted hills and twisting shoreline of Tomales Bay you can see the signature of 150 years of human activity upon the landscape. Remnants of the North Pacific Coast Railroad levee still cling to the eastern shoreline and abrupt changes in topography and vegetation reflect land use practices that have been modified by human needs and our understanding of natural processes. Changes in resource management are particularly evident at Livermore Marsh, a 26-acre wetland that is the centerpiece of Audubon Canyon Ranch's Cypress Grove Preserve.

The fascinating wetland we treasure at Livermore Marsh is quite different today from the estuary that was mapped in 1862 (see figure at right). In that era many people believed that nature's bounty was unlimited and that success could be measured by ones ability to overcome physical obstacles. To supply the booming population and industries surrounding San Francisco Bay, the North Pacific Coast Railroad was constructed in the 1870's through coastal Marin and Sonoma counties. This ambitious project included the construction of an earth levee and wooden bridge across the estuary. These structures affected flow characteristics and caused fine sediment from two small watersheds (approximately 1,600 acres) to accumulate behind the levee. During the next century, a rancher installed culverts through the levee to drain the marsh and increase seasonal pasture for grazing animals. This transformation of an estuary into a meadow is an example of how humans can influence habitat types by altering the hydro-geomorphic characteristics of a system. Hydro-geomorphology is the study of the interaction of water and geology that influences the earth's surface.

In 1971, Audubon Canyon Ranch (ACR) purchased the property with assistance from Marin Conservation League and named the wetland after Caroline Livermore, who dedicated enormous energy and resources toward environmental protection. As the management approach shifted from grazing toward preservation of wetland habitat, the marsh became an inspiring focus for the education program at Cypress Grove Preserve. When the extreme winter floods of 1982 eroded the levee, ACR decided to restore the levee and establish a coastal fresh water marsh, an increasingly rare habitat type along the California coast. This project included stabilization of the levee and the construction of a concrete spillway at the north end of the levee to retain fresh water. Because wetland conditions in the marsh were seasonal, four small ponds were created in the lower marsh to maintain aquatic habitat throughout late summer and fall. These projects were accomplished with assistance from the California Coastal Conservancy.



Portion of the U.S. Coast Survey of Tomales Bay, 1862. Complex meanders, large areas of open water and variable channel widths suggest variations in depth and salinity in Livermore Marsh. Dynamic estuarine conditions such as these support a wide variety of plants and animals.

During the next fifteen years, winter storms continued to transport freshwater and sediment through the system. Sediment monitoring indicated that approximately 1.5 cm of fine sediment was deposited annually throughout the marsh. Open areas of fresh sediment were rapidly colonized by emergent vegetation, providing excellent cover for Virginia Rail, Common Yelllowthroat, Tricolored Blackbird and other species. Unfortunately, the growth of lush vegetation also slowed drainage of water and sediment into the bay, which reduced the storage capacity for storm water runoff.

In 1997-1998, El Niño weather patterns brought unusually prolonged periods of rain to the West Coast. After eight days of rain, an additional 2.5 inches of rain on 3 February produced a flood that overtopped the earth levee at Livermore Marsh. The 70-foot gap that quickly formed in the levee was a dramatic demonstration of the combined force of freshwater runoff and tidal circulation, two of the most powerful and persistent natural forces that shape our coastal environment.

Following the breach in the levee, John Kelly and I consulted with thirty wetland experts to evaluate other physical, climatic and biological characteristics of the Livermore Marsh watershed and Tomales Bay. We used this information to develop several project alternatives that were evaluated on the basis of predicted short-term and long-term effects on the variety and composition of plant and animal communities and populations of special status species. The primary question was whether ACR should attempt to re-estab-

RESEARCH & EDUCATION IN A DEVELOPING TIDAL MARSH

The primary goal of ACR's research in Livermore Marsh is to analyze relationships among the physical processes that drive restoration, and to integrate the results with biological assessments of vegetation patterns and avian use in the developing tidal marsh. The project includes the following research objectives and methods.

Hydro-geomorphology: *We will investigate the underlying relationship between tidal prism (volume of water exchanged over a tidal cycle) and the dynamics of inlet channel geometry as the developing marsh matures. Estimates of tidal prism in Livermore Marsh will be derived from salinity measurements, topographic surveys in 1999, 2000, and 2003, and associated contour maps with one-foot intervals. The maximum extent of tidal inundation will be delineated during spring-high tides. Inlet channel geometry will be measured from the bridge three times per year and during rainstorms and spring-tides when changes in channel dimensions are most extreme.*

Comparison between Livermore Marsh and mature tidal marshes: *We will compare results from the hydro-geomorphology component above with the five reference levee marshes in Tomales Bay in aerial extent of tidal inundation and inlet geometry. Reference marshes will be selected which represent "mature" or equilibrium systems that have been tidal for at least 25 years.*

Evaluate the applicability of existing models: *Data from Livermore Marsh and the reference sites will be used to assess the performance of available statistical models that were developed to predict the inlet characteristics of small tidal marsh systems in the San Francisco Bay area. This evaluation will indicate whether these models are appropriate for Tomales Bay.*

Assess changes in vegetation patterns: *The structure and composition of emergent vegetation will be monitored during peak foliage in 1999 and 2003, and compared with existing data collected from 1988 to 1993, prior to the reintroduction of tidal conditions. Long-term habitat changes will be evaluated using trend analysis of individual variables, and multivariate factors to account for principal dimensions of change.*

Document changes in avian use: *Breeding and wintering bird use will be estimated annually for five years, using standardized methods for resident bird counts. Data will be compared with earlier studies conducted from 1985 to 1995.*

Results of this five-year project will guide future management of ACR's wildlife sanctuaries and will be interpreted through the education program. Reports will be provided to the Gulf of the Farallones National Marine Sanctuary, Point Reyes National Seashore and San Francisco Water Quality Control Board, and be published in primary scientific journals.

lish the freshwater marsh conditions or maintain the natural connection that had been re-established between the freshwater drainage and the bay. After careful consideration of the alternatives, ACR decided to install a bridge across the tidal inlet and take advantage of this unique opportunity to study the relationship between physical and biological processes in the developing tidal system. (See sidebar: Research and Education In A Developing Tidal Marsh).

The primary goal of the five-year study is to analyze relationships among physical processes that drive restoration and integrate the results with biological assessments of vegetation patterns and avian use. The study was designed by John Kelly, Katie Etienne and Rachel Kamman. Rachel is an independent Civil Engineer specializing in hydraulic and hydrodynamic modeling and the restoration of estuarine and river systems. We are also fortunate to have the assistance of Ellen Blustein, an experienced birder who is conducting the winter and breeding bird studies in Livermore Marsh.

We recognize that resource management continues to reflect societal values and our perceived relationship with nature. Therefore, we appreciate this opportunity to conduct a combined research and education program that will contribute to the successful restoration and appreciation of coastal marsh ecosystems. ●

Katie Etienne, ACR's Research Coordinator, applies her special interests in riparian and marine ecology and hydrology to the protection and restoration of coastal watersheds.

Audubon Canyon Ranch • Research and Resource Management

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Rebecca Anderson-Jones, *Bouverie Preserve*
Greg deNevers, *Bolinas Lagoon Preserve*

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David Franks, *Bolinas Lagoon Preserve*
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Helen Pratt
W. David Shuford
Rich Stallcup

◗ In Progress (see also back page)

Visiting investigators ◗ Carla D'Antonio and Jeff Corbin of UC Berkeley, and John Maron of University of Washington are studying the effects of invasive species on nitrogen retention in the coastal prairie at Tom's Point, on Tomales Bay. Sarah Eppley, of UC Davis, is studying segregation by sex in salt grass (*Distichlis spicata*) at Walker Creek Delta, on Tomales Bay. Keith Knudsen of William Lettis & Associates, is investigating evidence of earthquake-induced land level changes in marsh sediments at Tom's Point and Olema Marsh, on Tomales Bay. Oona McKnight, from the Sonoma Watershed Station of Sonoma Ecology Center, is monitoring thermal conditions in Stuart Creek, on the Bouverie Preserve, as part of a watershed assessment of steelhead trout habitat. UC Berkeley students Michael Lightwiser and Gian-Marco Pizzo of conducted a preliminary study of sedimentation and tidal inundation at Livermore Marsh. At Cypress Grove, visiting scientist Paul Spitzer of the Cooperative Oxford Lab (NOAA) in Maryland investigated winter distributions, toxicology, and molt cycles of Pacific Coast loons.

In progress: project updates

See also pages 3, 5 and 7.

Biodiversity database ◗ We are establishing a database for general inventory and monitoring of biodiversity on ACR sanctuaries. The system is built on database programs developed by the Information Center for the Environment (ICE) at U. C. Davis for the United Nations Man in the Biosphere Reserve System. ACR is a managing member of the Golden Gate Biosphere Reserve.

Tomales Bay plant species database ◗ Grant Fletcher continues to track populations of Point Reyes bird's beak (*Cordylanthus maritimus* ssp. *palustris*, SCROPHULARIACEAE), a rare salt marsh annual in Tomales Bay. He and coauthor Margriet Wetherwax recently published a paper on populations of *Castilleja ambigua* ssp. *humboldtiensis*, another rare salt marsh annual in Tomales Bay and Mendocino County (1999, *Madroño*, in press).

Shorebirds ◗ ACR has completed its tenth year of monitoring shorebird populations on Tomales Bay! Each of eight baywide counts each year requires 15-20 qualified shorebird observers, most of whom have contributed to the project for several years. The project is generating information on habitat use, population variation, and seasonal timing of shorebirds (see article, page 1).

Tide channels scour Livermore Marsh (story on page 6). *PHOTO BY LEN BLUMIN*

Common Raven ◗ ACR staff, in collaboration with the Point Reyes Bird Observatory and the Point Reyes National Seashore, has initiated a study of nest predatory behavior of the Common Raven. The study includes radio telemetry, road (abundance) surveys, nest monitoring, and behavioral study, with an emphasis on nest predation at colonial waterbird sites. Volunteer field observers have an important role in documenting the activities of ravens in the San Francisco Bay region.

Cape ivy control ◗ Resource Management Associate Len Blumin has made substantial progress in removing cape ivy (*Delairia odorata*) from ACR's Volunteer Canyon. He has accelerated the effort this year, coordinating many volunteer assistants and one part-time paid worker. Len expects to eliminate cape ivy from the area above the biologist's residence by the end of the 1999.

North Bay Counties Heron and Egret Project ◗ We are compiling the ninth year of monitoring data for all known heron and egret colonies in the northern San Francisco Bay area. ACR's Picher Canyon heronry at Bolinas Lagoon suffered devastating nest predation by Common Ravens in 1998, causing most Great Egret nests to fail. After many publications and more than 30 years of intensive work at the Picher Canyon heronry, Helen Pratt has retired from regular field study. Ray Paula is taking up the challenge of monitoring the individual fates of ACR's heron and egret nests. John Kelly's work on herons and egrets focuses on regional patterns of disturbance and spatial relationships among colony sites.

Hydrogeomorphology of a developing tidal marsh ◗ In 1998, winter floods converted ACR's Livermore Marsh at Cypress Grove Preserve on Tomales Bay, from a coastal freshwater to a tidal system (see article on page 6). Following a decision to manage the marsh as a natural tidal system, Katie Etienne, Rachel Kamman and John Kelly initiated a study to examine the influence of tidal circulation on the geometry of the tidal inlet. Because such fundamental physical processes influence the ecological character of tidal marshes, results of this research may benefit future restoration planning.

Oak restoration ◗ The blue, coast live and valley oaks planted at Bouverie Preserve eleven years ago continue to grow slowly. Soon, new photopoints will be established in this area for monitoring oak growth while concurrently documenting seasonal changes in the flora of adjacent vernal swales.

Newt populations ◗ We are examining 12 years of newt surveys at Bouverie Preserve. Red-bellied newts (*Taricha rivularis*) consistently comprise more than ninety percent of all newts sampled at Bouverie each spring. High numbers typically correspond with moderate spring temperatures and high humidity or precipitation.

Winter waterbirds on Tomales Bay ◗ John Kelly and Sarah Tappen recently published a paper on the value of Tomales Bay to wintering waterbirds (1998, *Western Birds* 29: 108-120). The paper summarizes seven years of waterbird monitoring. Waterbird surveys are continuing with support from the Point Reyes National Seashore. Excellent birders are needed to help census winter waterbirds by boat.

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