Research and
Resource Management
at Audubon Canyon Ranch

THE ARDEID

- 25 years of heron and egret monitoring Marin Islands
- tidal return Livermore Marsh
- population explosion introduced turkeys
- bird biodiversity report Tomales Bay
- ACR's other science agenda visiting investigators

2003

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Cover photo: Common Goldeneye by Kenneth W. Gardiner ◗ Ardeid *masthead Great Blue Heron ink wash painting by Claudia Chapline*

Audubon Canyon Ranch Research and Resource Management

The Watch

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Twenty-five years of heron and egret monitoring at the Marin Islands

A Tale of Two Islands

by John P. Kelly

The Marin Islands rise steeply from the bay shallows near San Rafael, like displaced chunks of the surrounding hills. One is forested with eucalyptus and pines; the other is grassy and more open, but lush buckeye and blackberry canopies mantle the northeast side, and these are adorned each spring and summer with hundreds of nesting herons and egrets. The islands are beautiful. Relatively undisturbed relicts of an earlier time, they sit just off the mostly urbanized shoreline of the San Francisco Estuary, a reminder that the lives of birds and humans are intertwined. And in the classic words used by Dickens to portray societal extremes, the heronry has seen "the best of times" and "the worst of times."

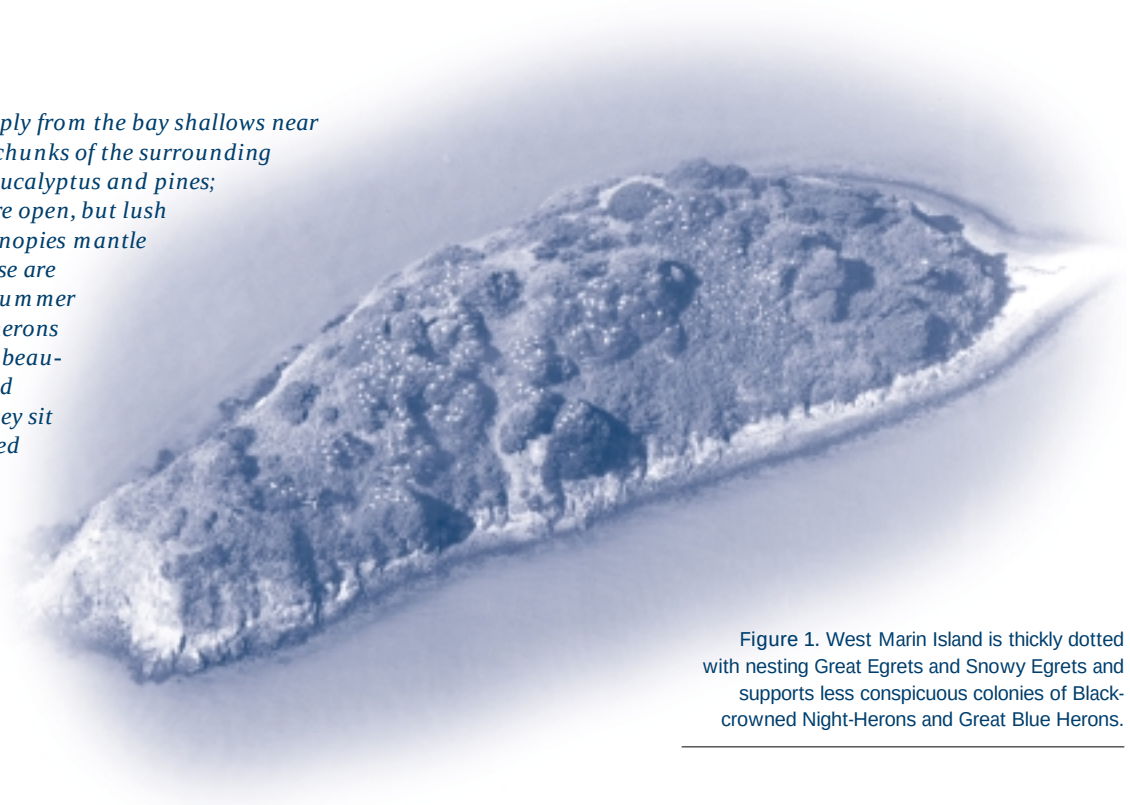

Figure 1. West Marin Island is thickly dotted with nesting Great Egrets and Snowy Egrets and supports less conspicuous colonies of Black-crowned Night-Herons and Great Blue Herons.

In 1979, Helen Pratt and others from the Marin Audubon Society began monitoring the numbers of nesting herons and egrets on West Marin Island (Figure 1). In 1993, when the Marin Islands became a National Wildlife Refuge, Audubon Canyon Ranch began making repeated visits each nesting season to track the reproductive performance of individual Great Egrets and Great Blue Herons (Kelly et al. 1994–1997, Kelly and Fischer 1998–2003). As many as 900 pairs of herons and egrets settle on West Marin Island in a good year—a concentration of reproductive activity that stands out distinctly among heronries in the San Francisco Bay area (more than 60 heronries are monitored each year by ACR; Kelly et al. 1993). The Marin Islands may therefore have a strong influence on the dynamics of regional heron and egret populations. With this potentially critical role of the heronry in mind, observers of the Marin Islands have experienced seasons of hope as well as seasons of despair.

Keeping watch

Each year, Binny Fischer and I map the locations of Great Egret and Great Blue Heron nests on panoramic photographs. We use telescopes to monitor nest survivorship, seasonal timing based on behavioral stages, and number of young fledged from the numbered nests. To count the numbers of nests, we drift slowly by boat around the colony and then compare totals with estimates made with telescopes from East Marin Island. Great Blue Herons typically nest on the highest branches, and they often land conspicuously on the highest perches as they approach their nest sites. Great Egrets build nests everywhere on the outer surface of tree canopies, with one to four young per nest standing patiently among the ubiquitous white catkins of the buckeyes. Black-crowned Night-Herons and Snowy Egrets often conceal their nests beneath blackberry or poison oak and go undetected during our counts. However, comparisons with aerial photographs and colony-based counts indicate that our annual surveys effectively track changes in colony size.

Colony size trends and variability

Occasionally, herons and egrets fly to East Marin Island to collect nest sticks. With the exception of one (failed) Great Blue Heron Nest in 1999, heron and egret nests are established only on the western island. Yearly fluctuations in the number of heron and egret nests have been considerable (Figure 1). This is expected, however, because colonial herons and egrets belong to larger populations that shift annually in their relative use of colony sites.

To further complicate explanations of annual differences, local influences may or may not affect nesting densities. On 4 July 1981, a fire burned about 1.5 acres of nesting habitat on the northwest slope of the West Marin Island, killing about 100 young Snowy Egrets and Black-crowned Night-Herons (Pratt 1983). Even so, nesting densities in subsequent years

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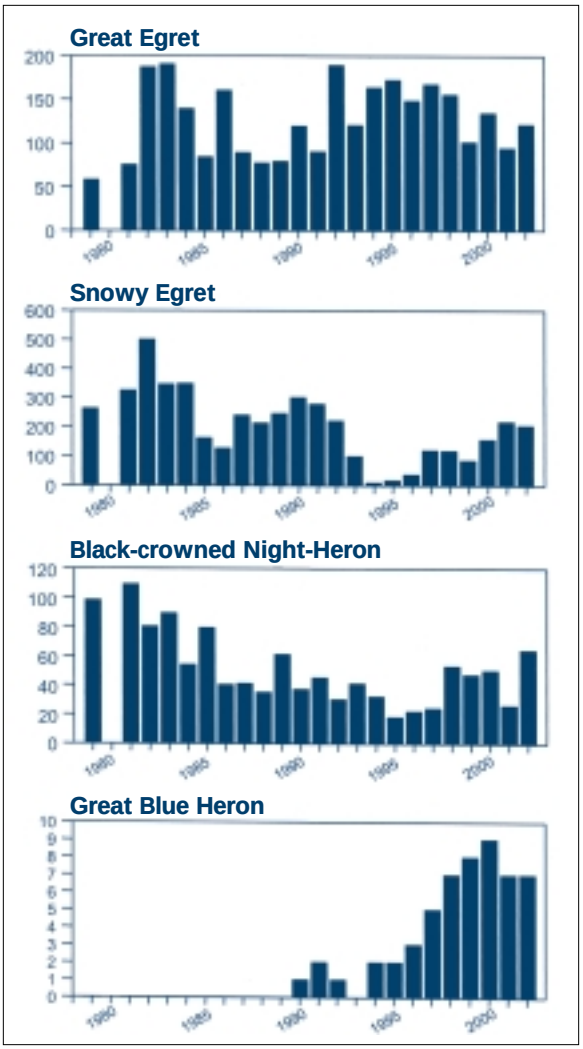

Figure 1. Number of active heron and egret nests observed on West Marin Island, 1979–2002.

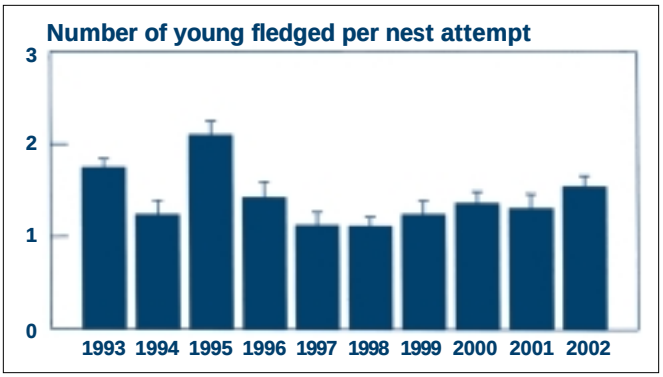

Figure 2. Number of Great Egret young produced per nest at West Marin Island, 1993–2002 (mean prefledging brood size adjusted for overall nest survivorship; error bars = standard errors).

remained high (Figure 1). In July 1955, 53 egrets (mostly Greats and a few Snowies) were "wantonly slaughtered…by rifle-bearing target shooters" (Pratt 1993). The culprits were arrested and, fortunately, egrets continued to nest on the island. Short-term increases and declines in the numbers of Great Egrets nesting on West Marin Island have occurred but no long-term trends are evident (Figure 1), and the productivity of Great Egrets has been fairly stable (Figure 2). These patterns are encouraging, especially in light of recently intense nest predation by Common Ravens, which has been a regular fact of life in the heronry since 1993 (see below).

Regional dynamics

Black-crowned Night-Herons at West Marin Island have shown a gradual decline, followed by possible recovery over recent years (Figure 1). But we have seen reciprocal changes in the number of night-herons on Alcatraz and other islands in the bay. As nesting distributions shift, smaller heronries are more likely to be abandoned. More rarely, herons and egrets may desert large colony sites, such as Bair Island in South San Francisco Bay, which was abandoned after heavy predation by non-native red fox. So, regional populations are more stable than suggested by the fluctuating numbers at the Marin Islands or other sites. Great Blue Herons began nesting on West Marin Island in 1990, soon after a nearby heron colony was abandoned.

The shifting distribution of Snowy Egrets clearly illustrates the regional connectivity of heronries. In 1993, Snowies began drifting away from West Marin Island to other colonies in the region (Figure 3). The shift was apparently the result of repeated harassment by a single Red-tailed Hawk (we found no evidence of predation). The mischievous hawk caused frequent fly-ups of Snowies for weeks during their early stages of courtship and nest initiation. This harassment continued into 1994, when finally all but eight pairs of Snowies abandoned the island. Coincidental increases in the numbers of Snowy Egrets soon became evident at several other colonies in the region, from nearby Red Rock and Brooks Islands to distant sites in Napa County and Suisun Marsh. The number of

Great Egret

KENNETH W. GARDINER

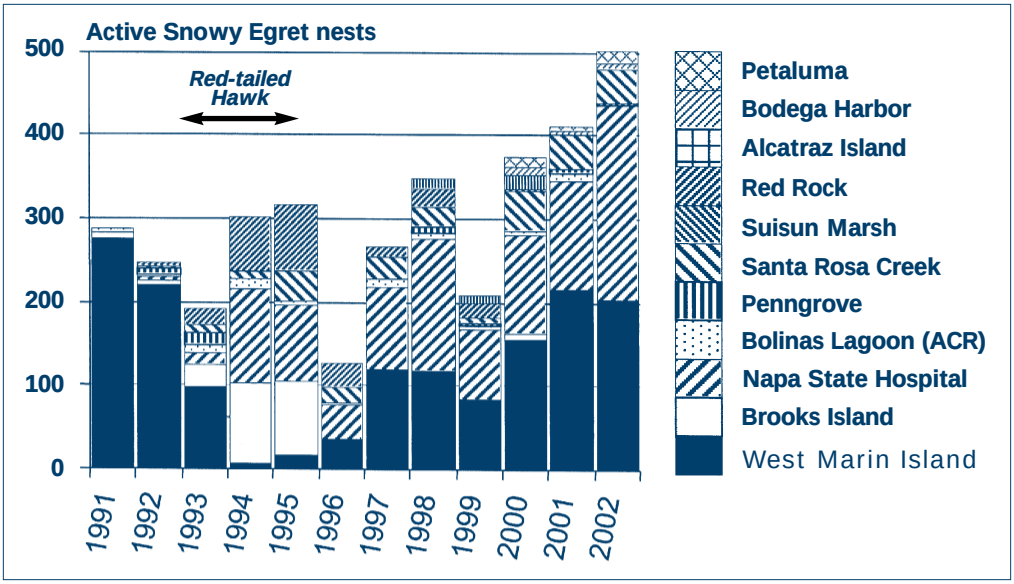

Figure 3. Number of active Snowy Egret nests at colony sites in the northern San Francisco Bay area, 1991–2002. The presence of a single Red-tailed Hawk on the Marin Islands in 1993–1994 coincided with regional shifts in nesting distribution.

Snowies nesting on West Marin Island has gradually recovered in recent years, perhaps partly because of previous breeders returning to the island and partly because of an apparent regional increase in recruitment (Figure 3).

Resident predators

Common Ravens nest each year on East Marin Island, frequently spending time in the heronry on West Marin Island. Dramatic increases in the numbers of Common Ravens in the San Francisco Bay area (Kelly et al. 2002) have focused concerns over possible increases in nest predation by Common Ravens in heronries (Kelly and Roth 2001).

Shell fragments and caches of food found near the raven nest confirm frequent pilfering of heron and egret eggs. Last year, we discovered prey remains indicating that resident ravens had captured and eaten at least 15 *adult* Snowy Egrets! A predominance of Snowy Egret eggs, young, and adults among raven prey remains suggests that Snowies might suffer greater nest predation by ravens than other heron or egret species, but we have not been able to test this possibility. By the time fledgling ravens from the eastern island are a week old, they are flying with their parents to the heronry where they spend extended periods of time, presumably learning to harvest heron and egret eggs and young.

Great Egret nestlings are left unattended and vulnerable to raven predation when they reach three to four weeks of age—when they no longer need brooding to stay warm and, presumably, both parents must search for food. If nestlings survive to five weeks, however, they become so large that their vulnerability to predation declines. The overall stability of the Great Egret colony over the last decade suggests that a heronry of this size may be able to tolerate the predatory activities of resident ravens. This may be possible in part because some egrets renest successfully after failure.

Western Gulls also nest on West Marin Island and occasionally prey on heron and egret nests. More rarely, Great-horned Owls and even Black-crowned Night-Herons are known to take nestling herons or egrets. However, most resident predators do not seem to threaten the heronry overall. Intense or continuing disturbance can destroy heronries but, so far, herons and egrets at the Marin Islands have been able to rebound from such episodes. Their ability to withstand such challenges, season after season, is perhaps good reason for hope. ■

KENNETH W. GARDINER

Snowy Egret

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Breeding and winter bird use in Livermore Marsh

The Return of Tidal Circulation

by Katie Etienne

As I set aside competing thoughts and inhale the morning breeze sweeping across the east shore of Tomales Bay, I become aware of the diverse community of birds that have been active since first light. I move very slowly, until Ellen Blustein reminds me to walk at a moderate speed while she records the position of each bird. We follow an established route, weaving among tules, willows, and sedges. If a bird utters an alarm call, Ellen pauses briefly to identify all birds responding to the call, and pays particular attention to departing birds to avoid counting them again in different locations. Ellen's talent for recalling song fragments, key physical characteristics, and subtle behavioral clues are crucial for an effective census. The eight winter and eight breeding bird counts conducted each year are part of a five-year research project by Audubon Canyon Ranch (ACR) to examine physical changes, vegetation structure, and bird use after the reintroduction of tidal circulation in Livermore Marsh.

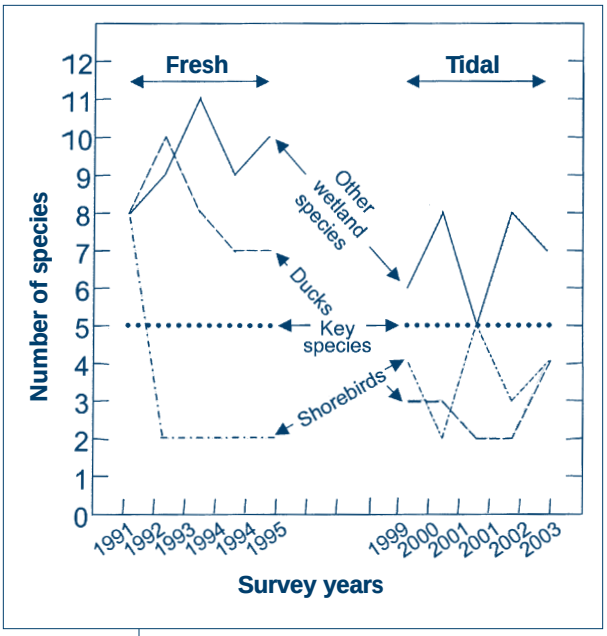

Figure 1. Annual number of winter bird species in Livermore Marsh during freshwater (1991–1995) and tidal (1999–2003) periods.

Following the storm-water breech of the North Pacific Coast Railroad levee at Cypress Grove in 1998, the temporary freshwater marsh was transformed into a gradient of fresh, brackish, and tidal conditions. The proportions of these wetland types are determined by changes in the elevation of the marsh plain and developing tide channels, which are measured periodically with topographic surveys (see *Ardeid* 2001). We anticipated that this tidal restoration project would also alter the vegetation in the lower marsh and reduce the use of the marsh by some bird species, but we recognized that a self-maintaining tidal marsh will eventually support a net increase in overall biodiversity. Previous studies by John Kelly and Katie Fehring, conducted when Livermore Marsh was a freshwater system (1991–1995), provide an opportunity to measure changes in vegetation and avian use under developing tidal conditions (1999–2003).

As predicted, the winter and breeding surveys indicate a decline among some bird species during the first five years of the tidal period; a few species increased in abundance and most of the 98 species remained stable. However, it is important to understand that extrinsic factors such as weather, regional and continental changes in bird populations, and land use patterns also influence current population estimates. With this caveat in mind, I invite you to consider data for 34 species that are most directly affected by habitat changes in the lower marsh. To facilitate this comparison, we separated these wetland birds into four groups prior to analysis. Other birds species continue to use the marsh but are probably unaffected by changes in tidal conditions (see box at left).

Winter and breeding bird use in the lower marsh

The annual number of wintering species decreased in two of the four groups using the lower marsh (Figure 1). Thirteen species of diving and dabbling ducks used Livermore Marsh during the ten study years. Winter abundance declined significantly for seven duck species during the tidal period, and six duck species were stable across all winter counts. The only exception was Red-breasted Merganser, which was

Bird species not likely to show effects of tidal reintroduction

Many wintering, breeding (*), and visiting species use riparian or seasonal freshwater vegetation that is unaltered by tidal reintroduction.

Cattle Egret
Green Heron
Gadwall
Common Goldeneye
Osprey
Turkey Vulture
White-tailed Kite
Northern Harrier*
Red-tailed Hawk
Sharp-shinned Hawk
Cooper's Hawk
Red-shouldered Hawk
American Kestrel
California Quail*
Common Moorhen
Mourning Dove*
Anna's Hummingbird*
Allen's Hummingbird*
Downy Woodpecker
Nuttall's Woodpecker
Northern Flicker
Say's Phoebe
Western Wood-Pewee
Ash-throated Flycatcher
Warbling Vireo
Hutton's Vireo
Western Scrub-Jay*
American Crow
Common Raven
Violet-green Swallow
Northern Rough-winged Swallow
Barn Swallow
Tree Swallow
Cliff Swallow*
Chestnut-backed Chickadee*
Common Bushtit*
Bewick's Wren*
Golden-crowned Kinglet
Hermit Thrush
American Robin
Swainson's Thrush*
Varied Thrush
Wrentit*
European Starling
American Pipit
Yellow Warbler
Orange-crowned Warbler
Yellow-rumped Warbler
Wilson's Warbler*
Spotted Towhee
California Towhee*
Savannah Sparrow
Fox Sparrow
Lincoln's Sparrow
White-crowned Sparrow
Golden-crowned Sparrow
Dark-eyed Junco
Black-headed Grosbeak*
Western Meadowlark
Brewer's Blackbird*
Brown-headed Cowbird*
Northern Oriole
Purple Finch*
House Finch*
Pine Siskin
American Goldfinch*
House Sparrow

The number of Marsh Wrens using Livermore marsh has remained stable year-round, despite tidal-induced reductions in cattail and bulrush cover.

observed only during the tidal period, in the winters of 2000 and 2003. The loss of persistent (non-tidal) open water in the lower marsh probably accounts for the absence of three species of nesting ducks during tidal surveys (Table 1).

Ten species of shorebirds were recorded during at least one winter survey. The number of shorebird species was higher during the 1991 census and probably corresponds to the end of a drought that had prevented flooding of shallow areas of the marsh plain until mid-winter. The greater variation in shorebird richness recorded during the tidal period probably occurred because censuses were not conducted during consistent tide levels. The increase in shorebird richness during the tidal period is due primarily to the presence of Spotted Sandpipers and Western Sandpipers. The density of winter Killdeer also increased significantly during the tidal period. In contrast, Semipalmated Plovers, Willets, Dunlins, and Long-billed Dowitchers were observed during the freshwater period but not during the tidal period. Of course, these values do not represent changes in the populations of these birds, for all of these species are common to the Tomales Bay shoreline and are frequently observed foraging on the expanding delta just beyond Livermore Marsh.

Audubon Canyon Ranch previously identified six "Key species" for wetland management: Virginia Rail, Marsh Wren, Common Yellowthroat, Song Sparrow, Red-winged Blackbird, and Tricolored Blackbird. Although Tricolored Blackbirds typically winter in other nearby habitats and are not commonly observed in coastal marshes, large numbers (250 to 500 nests!) were observed during the breeding seasons of 1988, 1989, and 1992. More Virginia Rail territories were detected during the freshwater period, while Marsh Wrens remained stable year-round and Song Sparrows reached higher winter and breeding densities during the tidal period.

We predicted that 14 "Other wetland species" would also be influenced by changes in the tidal regime (Figure 1). Winter richness in this group was higher during the freshwater period, and five of these species were significantly more abundant during the freshwater versus the tidal period, while the number of Great Egrets and Black Phoebes increased during the recent tidal period (Table 1).

Fifteen of the 34 selected species held breeding territories during at least one five-year period (Table 1). Common Yellowthroat, Song Sparrow, and Killdeer had significantly more territories during the tidal period, and nine territorial species nested in significantly greater numbers during the freshwater period. One Sora territory was suggested by three observations in 1999, but evidence of nesting Soras has not been confirmed. Virginia Rails were heard several times in 2001, but vocalizations never lasted long enough to confirm territories. Nevertheless, we know Virginia Rails continued to nest in the marsh because Ellen observed chicks in February, which indicates they can breed before the breeding bird censuses are conducted. Killdeer chicks were recorded only in 2003 but, as with Belted Kingfishers and Black Phoebes, they were known to nest in nearby areas.

These observations demonstrate the dynamic changes that are occurring, and we are encouraged that Livermore Marsh continues to support a diverse avian community. In spite of the expected decline in use by freshwater bird species, we look forward to the development of a self-sustaining tidal marsh with a high diversity of plankton, zooplankton, plants, and invertebrates, and the enhanced primary and secondary productivity that drives tidal ecosystems. ■

Table 1. Winter densities and breeding bird territories during freshwater (1991–1995) vs. tidal (1999–2003) conditions. Symbols indicate significantly greater numbers during freshwater (F>T) or tidal (F<T) conditions ($P < 0.05$). Zero (0) indicates species that were absent during the tidal period. Dash (–) indicates non-significant differences. Blank indicates absence during both periods.

Species	Winter	Breeding
Diving & dabbling ducks		
American Wigeon	F>T	
Mallard	F>T	F>T(0)
Cinnamon Teal	F>T	F>T(0)
Northern Pintail	–	
Northern Shoveler	–	
Green-winged Teal	F>T(0)	
Canvasback	F>T(0)	
Ring-necked Duck	–	
Greater Scaup	–	
Bufflehead	F>T	
Hooded Merganser	–	
Red-breasted Merganser	–	
Ruddy Duck	F>T	F>T(0)
Shorebirds		
Semipalmated Plover	–	
Killdeer	F<T	F<T
Greater Yellowlegs	–	
Willet	–	
Spotted Sandpiper	–	
Western Sandpiper	–	
Least Sandpiper	–	
Dunlin	–	
Long-billed Dowitcher	–	
Common Snipe	–	
Key species		
Virginia Rail	–	F>T
Marsh Wren	–	–
Common Yellowthroat	–	F<T
Song Sparrow	F<T	F<T
Red-winged Blackbird	F>T	–
Tricolored Blackbird		F>T(0)
Other wetland species		
Pied-billed Grebe	F>T	F>T(0)
Eared Grebe	–	
Great Egret	F<T	
Snowy Egret	–	
Great Blue Heron	F>T	
Black-crowned Night Heron	F>T(0)	
Sora	–	–
American Coot	F>T	F>T(0)
Mew Gull	–	
Glaucus-winged Gull	–	
Belted Kingfisher	–	F>T
Black Phoebe	F<T	F>T
Winter Wren	–	
Swamp Sparrow	F>T(0)	

Tidal reintroduction appears to have improved conditions for Song Sparrows in lower Livermore Marsh.

PHOTOS BY PETER LATOURRETTE

California's latest population explosion

Introduced Turkeys

by Daniel Gluesenkamp

DANEIEL GLUESENKAMP

Sonoma State University students participate in ACR's turkey exclusion experiment during a Restoration Ecology class field trip to the Bouverie Preserve. Biology students were taught principles of experimental design as they assisted with plot set-up and initial data collection. The ongoing three-year experiment evaluates the impact of introduced turkeys on native ecosystems.

California is in many ways an ecological island, isolated by the Pacific Ocean to the west and by expansive deserts on the east. This isolation fueled tremendous innovation in California's plants, animals, and ecological communities; for example, nearly a third of California plant taxa are unique to the California floristic province. This era of isolation ended when European colonization connected California to the rest of the world, introducing new species and interactions, and presenting interesting challenges to preservation of California's indigenous biodiversity.

Wild Turkeys *(Meleagris gallopavo)* are among the most interesting challenges introduced to California. Though native to other parts of North America, Wild Turkeys never successfully colonized California (Burger 1954), and California's ecosystems have evolved in the absence of large galliform birds.

In November 2002 I initiated the first experimental assessment of turkey impacts in California, a central component of Audubon Canyon Ranch's Turkey Invasion Program. The objectives of the program include conducting scientific experiments to evaluate the ecological impacts of introduced turkeys, mapping the distribution and abundance of turkeys, and working with other researchers, conservationists, and the Department of Fish and Game to learn more about the ongoing invasion.

Introduction of turkeys to the Golden State

Introduction of turkeys to California began with an 1877 release on Santa Cruz Island (Small 1994). Attempts to establish populations for hunting continued with major state-sponsored release programs around 1910 and between 1928–1951 (Harper and Smith 1970). These early introductions failed to establish vigorous populations, probably due to the fact that the birds released were farm-raised and poorly suited to survive in the wild. In the early 1970s and 1980s, however, the California Department of Fish and Game began importing and releasing birds of the Rio Grande subspecies *(M. gallopavo intermedia)*. These birds were wild-caught in Texas, in habitats comparable to those found at the California release sites, and Rio Grande introductions have been very successful. Populations have increased very rapidly, ranges have expanded dramatically, and turkeys have become a common component of California west of the Sierra Nevada.

Very little is known about the population and community biology of introduced turkeys in California, or about impact on the systems that they invade. Introduced turkeys may negatively affect native systems indirectly (by competing with native species for resources, or via physical disturbance of soil and litter during foraging) or may directly impact native species (e.g. by eating them). Cursory diet studies have shown that introduced turkey diets are extremely broad. However, the nature and severity of turkey impacts are largely unknown; even in states where turkeys have been managed for a century, most research has focused on management for hunting, and surprisingly little is known about the ecology of this beautiful animal.

Understanding the turkey invasion

Quantifying the ecological impacts of introduced turkeys is an important first step in determining how to respond to this invasion. To measure these impacts, I am using cage exclosures to manipulate turkey abundance and examine two pathways by which turkey invasion may affect ecological systems in Sonoma: direct impacts via consumption of prey items and indirect impacts of foraging disturbance. This experiment will quantify turkey effects on vegetation structure and composition, on invertebrate abundance and composition, and on the consumption of specific food items such as acorns and salamanders. The study will also assess the utility of tools likely to be used in future turkey studies and management programs, and will test assumptions, such as inefficient foraging and low prey encounter rates, that have led the Department of Fish and

Table 1. Partial list of plant genera found in Wild Turkey food habit literature (Smith and Browning 1967, DFG 2001). Turkey gizzards grind food beyond recognition, making accurate dietary studies extremely difficult, and their diets are seasonally variable. However, even incomplete dietary studies demonstrate that introduced turkeys consume an enormous variety of food items. Turkey dietary breadth may have dire consequences for native biodiversity; of 194 rare and special status plant taxa that occur in Marin and Sonoma counties, 35% (64 taxa) occur in genera listed below (CalFlora 2003). While details are less well known than for plants, turkeys also consume a variety of animals, including invertebrates, reptiles, amphibians, and even other birds.

Acacia	*Callicarpa*	*Euphorbia*	*Lotus*	*Poa*	*Sisyrinchium*
Achillea	*Calochortus*	*Fagopyrum*	*Ludwigia*	*Polygonatum*	*Smilax*
Actaea	*Carex*	*Fagus*	*Lupinus*	*Polygonum*	*Solanum*
Agoseris	*Carya*	*Festuca*	*Lycopodium*	*Polypodium*	*Solidago*
Agropyron	*Cassia*	*Forestiera*	*Madia*	*Polypogon*	*Sonchus*
Allium	*Castanea*	*Fragaria*	*Mahonia*	*Polystichum*	*Sorghum*
Alnus	*Ceanothus*	*Fraxinus*	*Medicago*	*Pontedenria*	*Sphenopholis*
Alopecurus	*Celtis*	*Galactia*	*Melica*	*Portulaca*	*Sporobolus*
Amaranthus	*Centella*	*Galium*	*Melitotus*	*Potentilla*	*Stellaria*
Ambrosia	*Centrosema*	*Gaura*	*Menispermum*	*Prosopis*	*Stillingia*
Ampelopsis	*Cerastium*	*Gaylussacia*	*Menodora*	*Prunus*	*Stipai*
Amphicarpa	*Chenopodium*	*Geranium*	*Microseris*	*Pseudotsuga*	*Styrax*
Amphicarpaea	*Chloris*	*Glycine*	*Mitchella*	*Psoralea*	*Symphoricarpos*
Amsinckia	*Chrysobalanus*	*Gyrotheca*	*Morus*	*Pteridophyta*	*Taraxacum*
Anagallis	*Cirsium*	*Hamamelis*	*Muhlenbergia*	*Pteris*	*Taxodium*
Andropogon	*Claytonia*	*Helianthus*	*Munroa*	*Purshia*	*Tephrosia*
Aneilema	*Cleome*	*Hepatica*	*Muscadinia*	*Pyrrhopappus*	*Toxicodendron*
Anemone	*Commelina*	*Hoffmansegia*	*Myrica*	*Pyrus*	*Tragopogon*
Anemopsis	*Cornus*	*Hordeum*	*Nassella*	*Quercus*	*Tricachne*
Apios	*Crataegus*	*Houstonia*	*Nasturtium*	*Ranunculus*	*Trifolium*
Aralia	*Crotalaria*	*Hydrocotyle*	*Nyssa*	*Ratibida*	*Triticum*
Arbutus	*Croton*	*Hymenoxys*	*Onoclea*	*Rhamnus*	*Tsuga*
Arctium	*Cynodon*	*Hypochaeris*	*Onosmodium*	*Rhus*	*Ulmus*
Arctostaphylos	*Cyperus*	*Hypoxis*	*Opuntia*	*Ribes*	*Umbellularia*
Ardisia	*Dactylis*	*Ilex*	*Orchidaceae*	*Robinia*	*Uniola*
Arisaema	*Danthonia*	*Ipomoea*	*Oreophila*	*Rosa*	*Vaccinium*
Aristolochia	*Daucus*	*Iris*	*Oryzopsis*	*Rubus*	*Vaseyochloa*
Artemesia	*Descuraima*	*Isoetes*	*Osmorhiza*	*Rudbeckia*	*Vemonia*
Asimina	*Descurania*	*Jatropha*	*Ostrya*	*Rumex*	*Verbascum*
Aster	*Desmodium*	*Juncus*	*Oxalis*	*Sabal*	*Verbena*
Astragulus	*Dichelostemma*	*Juniperus*	*Oxypolis*	*Sagittaria*	*Verbesina*
Avena	*Digitaria*	*Koeleria*	*Panicum*	*Salvia*	*Viburnum*
Axonopus	*Diodia*	*Krigia*	*Parthenocissus*	*Sambucus*	*Vicia*
Bemoin	*Diospyros*	*Lactuca*	*Paspalum*	*Sassafras*	*Vigna*
Berbis	*Dryopteris*	*Lantana*	*Pedicularis*	*Schismus*	*Viguiera*
Berchemia	*Echinochloa*	*Lappula*	*Persea*	*Scirpus*	*Viola*
Betula	*Elaeagnus*	*Lathyrus*	*Phacelia*	*Scleria*	*Vitis*
Bidens	*Elymus*	*Leptochloa*	*Phalanris*	*Scrophularia*	*Vulpia*
Blepharoneuron	*Epilobium*	*Lespedeza*	*Phleum*	*Senecio*	*Xyris*
Bouteloua	*Equisetum*	*Lessingia*	*Photinia*	*Serenoa*	*Zanthoxylum*
Brachypodium	*Eragrostis*	*Lilium*	*Physalis*	*Serinea*	*Zea*
Brassica	*Erigeron*	*Liquidamber*	*Picris*	*Setaria*	*Zizanopsis*
Briza	*Eriogonum*	*Lithospermum*	*Pinus*	*Shepherdia*	
Bromus	*Erodium*	*Lolium*	*Plagiobothrys*	*Silene*	
Bumelia	*Eupatorium*	*Lonicera*	*Plantago*	*Silybum*	

Game to conclude that additional turkey introductions will not harm rare and endangered species (DFG 2001).

While it is clear that turkey populations are expanding rapidly, there are almost no data regarding their size, their geographic range, or their rate of increase and expansion. I am currently planning a project that will map the abundance and distribution of turkeys in Marin and Sonoma counties. The mapping work is supported by the Sonoma Ecology Center, ACR's partner in this endeavor and a respected source of GIS (Geographic Information Systems) mapping expertise. Results of this study will provide scientists and conservationists with crucial information on turkey distribution and patterns of spread. The data will also enable us to predict which habitats are likely to be most affected by turkeys and to estimate how many turkeys we will have when population growth eventually levels off.

PETER LATOURRETTE

Invasive populations of Wild Turkey in California are derived from birds of the Rio Grande subspecies, introduced from Texas.

Finally, ACR is working with others to develop and share current information on the status of the turkey invasion. We have offered ACR preserves and expertise to university researchers and graduate students interested in studying the ecology and behavior of introduced turkeys. We helped convince the Department of Fish and Game to institute a moratorium on additional turkey introductions, and have met with leaders of DFG's turkey program to discuss conservation concerns associated with the spread of this non-native organism. It is our hope that by developing objective scientific data and then presenting well-supported conclusions to citizens, conservationists, and decision-makers, Audubon Canyon Ranch will make an important contribution to minimizing the impact of this new invader on California's precious biological diversity.

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A report on the All Taxa Biodiversity Inventory of Tomales Bay

Bird Alphabet Soup

by John P. Kelly

KENNETH W. GARDINER

Although currently rare, Clapper Rails may have been regular breeders in the tidal sloughs of Lagunitas Creek delta prior to the construction of levees in 1946.

How many bird species use Tomales Bay? In a recent report to the Point Reyes National Seashore, Audubon Canyon Ranch addressed this question in considerable depth, marking the first contribution to a planned All Taxa Biodiversity Inventory (ATBI) for Tomales Bay (Kelly and Stallcup 2003). The answer to this relatively simple question is complex and conditional, depending on the timing, frequency of occurrence, distribution among sub-areas, and detectability of species. Overall, the report reveals a surprising richness of birds, including rare visits by several unexpected species. Consider, for example, that in addition to the typical profusion of waterbirds, you have a better-than-zero chance, based on past records (Table 1), of seeing a Yellow-billed Loon, a Black Skimmer, or even a Magnificent Frigatebird on Tomales Bay!

The Tomales Bay ATBI is an ambitious project involving several independent investigators and organizations, currently coordinated by the Point Reyes National Seashore Association. Inventories of plankton, vascular and non-vascular plants, benthic and intertidal invertebrates, fishes, mammals, and birds will lead to a nearly comprehensive list of species in Tomales Bay. Existing and new information will be consolidated into a single geographic information system (GIS). Other objectives involve opportunities for education, strategies for habitat restoration, and plans for providing information to scientists and other interested individuals or groups. There remains much to do, with a wide range of potential benefits.

In the avian biodiversity report, Rich Stallcup and I analyzed 13 years of ACR shorebird and waterbird survey data, examined the results of numerous published and unpublished reports, and verified anecdotal records of bird species occurrences in Tomales Bay. The resulting list of species, keyed by taxonomic hierarchy, seasonality, special status categories, preferred habitats, relative abundance, and occurrence within 12 sub-areas, identifies 163 bird species known to occur or to have occurred in Tomales Bay, *below the mean higher high-tide level* (Tables 1 and 2). These include 122 species that occur regularly or occasionally and 41 species that occur very rarely, with fewer than five documented occurrences. Species normally associated with adjacent areas were included only if they occurred in habitats known to be suitable for their use. Other species, such as Brewer's Blackbird, which occasionally occurs along the shore, and Yellow Warbler, which might land or even forage rarely in salt marsh *Grindelia* shrubs, were not included. Similarly, bird species that occurred only by flying over the area at high elevations were not included. Extremely rare species records were included only if accepted by the California Bird Records Committee of Western Field Ornithologists.

The biodiversity report also recommends specific protocols for shorebird and waterbird surveys, based on ACR's ongoing (since 1989) monitoring programs on Tomales Bay (see *Ardeid*, Spring 1999 and Summer 1997). Each winter, ACR conducts three to four baywide waterbird surveys. Each survey requires a team of 12-15 observers who work from three 17-

RICH STALLCUP

Common Loons consistently occupy all areas of the bay in winter, whereas Red-throated and Pacific loons are most likely to occur between Cypress and Pelican points.

to 21-foot Boston Whalers or similar boats traveling in formation along parallel 18-km transects (Figure 1). ACR also completes six baywide shorebird counts each winter and one or more counts during each fall and spring migration period. Each shorebird count requires 15–20 observers who simultaneously record shorebird use among the bay's many tidal flats and beaches. ACR field observers on Tomales Bay have demonstrated a high level of expertise in this work, and most of them have been loyal to the program for many years.

Winter surveys recorded 58 species of "waterbirds" (not including shorebirds and medium-to-large gulls). The numbers of species detected during waterbird surveys were greatest between Pelican Point and Tom's Point (50 species, Figure 1) and along the east shore (51 species). Seasonal shorebird surveys detected 32 species, with the greatest richness of species occurring at Sand Point (28 species) and Walker Creek delta (26 species).

For the biodiversity inventory, we presented the bird survey results as probabilities of each species occurring among years and among surveys: by season; baywide and within each of 12 sub-areas; and as mean baywide abundances. Finer details of abundance variation and distri-

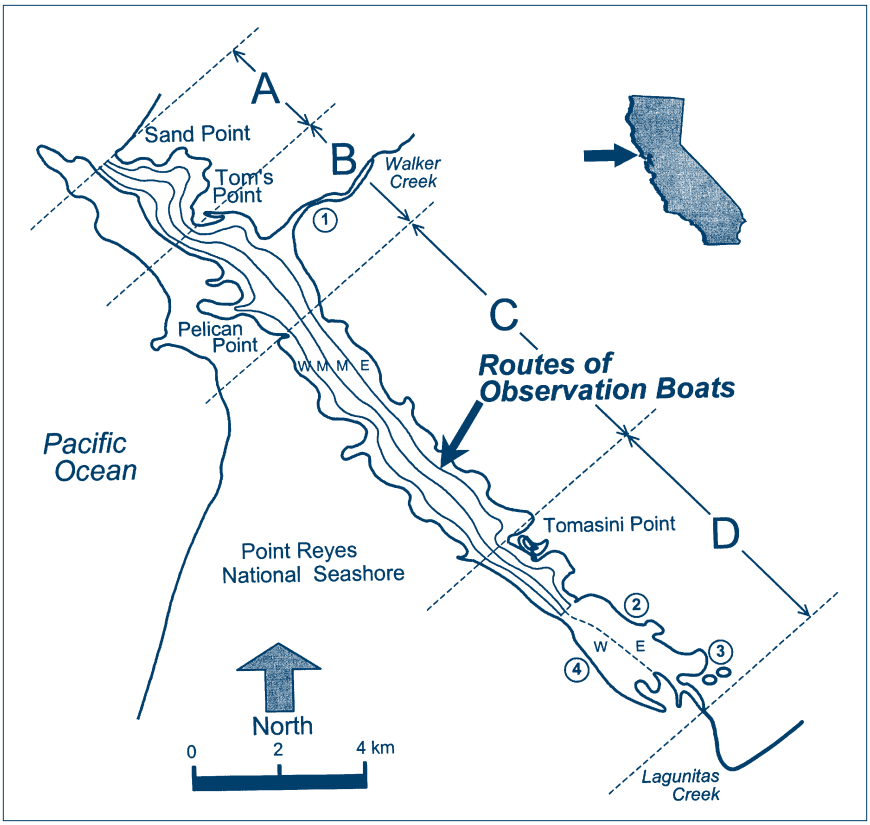

Figure 1. The All Taxa Biodiversity Inventory of Tomales Bay is based on ACR's winter waterbird count areas (A, B, C, D); sub-areas are marked by routes of observation boats along the west shore (W), mid-bay (M), and east shore (E). Supplementary waterbird counts (circled) are conducted at Walker Creek (1), Millerton Gulch to Bivalve (2), Bivalve (3), and Inverness (4).

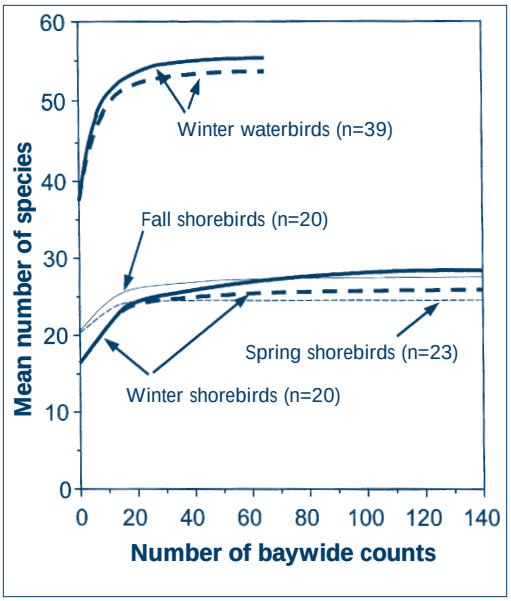

Figure 2. Species accumulation curves show the expected (mean) number of bird species detected for each level of effort (number of counts). Results for each level of effort are based on 100 random samples taken from 13 years of count data from Tomales Bay, 1989–2002. Bold, dashed lines indicate the expected number of species if surveys are limited to five years.

bution of birds have been evaluated in previous publications (e.g., Kelly and Tappen 1998; Kelly 2001a, 2001b). Overall, our work to date provides a thorough assessment of habitat values and bird use in Tomales Bay.

To determine the optimal effort needed for future inventories, we examined randomized species accumulation curves (Figure 2). These analyses suggested that most bird species in Tomales Bay could be detected by conducting 20–35 baywide waterbird surveys over five winters and 20–30 baywide counts of shorebirds over five years, for each of the winter, fall migration, and spring migration periods. The few additional species expected with additional effort typically represent rare visitors or vagrant species that do not normally occur in the bay.

Based on species occurrences in other areas along the Pacific Coast, Rich Stallcup identified five species that have not been detected but are likely to be found in Tomales Bay in the near future: Arctic Loon, Northern Fulmar, Steller's Eider, Wilson's Phalarope, and Sabine's Gull. These and other species most likely to be added to the list include difficult-to-observe pelagic visitors, species with expanding ranges, and rare species that have been observed elsewhere along this part of the Pacific Coast.

Over all, the avian biodiversity inventory of Tomales Bay reveals not only an estuary that is enriched by numerous visiting rarities, but also a habitat area that supports an impressive array of coastal and estuarine birds. ■

Turn to pages 10–12 for the table of birds occurring in Tomales Bay.

KENNETH W. GARDINER

Western Grebes occur throughout Tomales Bay and form stable winter rafts near Cypress Point and Marconi Cove.

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Table 1. (Pages 10–12.) Documented bird species occurrences on Tomales Bay prior to January 2003. "X" indicates documented presence in a sub-area; actual patterns of bird use may be broader than indicated if species occur in areas where they have not yet been detected. See Figure 1 (page 9) for sub-areas. See Table 2 (below) for legend of symbols used.

SPECIES	SEASONAL STATUS	SPECIAL STATUS	PREFERRED HABITAT	RELATIVE ABUNDANCE	SUB-AREAS															
					AE	AM	AW	A	BE	BM	BW	B	CE	CM	CW	C	DE	DM	DW	D
Yellow-billed Loon	W		OB	Cs					X			X	X			X			X	X
Common Loon	W	CSC,BMC	OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pacific Loon	W		OC,OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Red-throated Loon	W		OC,OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Horned Grebe	W		OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eared Grebe	W		OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Red-necked Grebe	W		OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Western Grebe	W		OC,OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Clark's Grebe	W		OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pied-billed Grebe	R*		OB,FM	U	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Sooty Shearwater	LM		OC	X														X		X
Fork-tailed Storm-Petrel	LR	CSC	OC	X						X		X	X			X				X
Ashy Storm-Petrel	LR	FSC,CSC,BMC	OC	X													X			X
Red-footed Booby	S			X		X		X												
American White Pelican	S	CSC,WL	OB	C	X	X		X	X	X		X	X			X	X			X
Brown Pelican	S	FE,SE,BMC	OC,OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Double-crested Cormorant	R*	CSC	OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brandt's Cormorant	R		OC,OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Pelagic Cormorant	R		OC,OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X
Magnificent Frigatebird	S		A	X										X		X		X		X
American Bittern	R	FSC	FM	X					X			X								
Great Blue Heron	R*	BMC	M,FM,SM	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Great Egret	R*		M,FM,SM	C	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Snowy Egret	R	FSC,CSC	M,FM,SM	U	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Little Blue Heron	S		M,FM,SM	X					X			X	X			X				
Black-crowned Night-Heron	R*	FSC	M,FM,SM	U									X			X				
Turkey Vulture	R*		A	C	X			X	X		X	X	X			X				
Ross's Goose	W		FM,G	Cs	X			X		X		X								X
Emperor Goose	W		FM,M,G	X																X
Snow Goose	W		FM.G	X	X			X												
Greater White-fronted Goose	W		FM,G	X										X		X				
Canada Goose	W*		FM.G	U	X	X		X	X	X		X					X			X
Cackling Canada Goose	W		FM.G	X	X			X												
Aleutian Canada Goose	W	FT	FM.G	X						X		X								
(Black) Brant	W		OB,SM	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
(American) Brant	W		OB,SM	X	X			X	X			X								
Tundra Swan	W		G	Cs	X			X									X			X
Mallard	W		FM,SM	U	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X

Table 2. Categories and symbols used to summarize information on bird species of Tomales Bay (Table 1). Species names from: American Ornithologist's Union. 1998. Checklist of North American Birds. 7th Edition. American Ornithologist's Union, Washington, D.C.

SEASONAL STATUS

- W Mostly winter
- M Fall and or spring migrant
- S Mostly summer
- R Resident; present all year
- L Local visitor from nearby habitat areas
- * Known to nest or have nested in the area

SPECIAL STATUS

- FE Federally listed as Endangered
- FT Federally listed as Threatened
- FSC Federal Special Concern species (former Category 2 candidates)
- FD Federally delisted (monitoring)
- BMC Migratory Nongame Birds of Management Concern, U.S. Fish and Wildlife Service
- SE State-listed as Endangered
- ST State-listed as Threatened
- CSC California Special Concern species, State Department of Fish and Game
- WL Audubon Watch List for California
- PIF Partners in Flight Watch List

PREFERRED HABITAT

- OB Open water of bays or estuaries
- OC Outer coastal water, nearshore or pelagic
- M Mudflat and shallowly flooded areas free of upright vegetation
- FM Freshwater marsh or ponds
- SM Saltmarsh
- R Rocky shore
- C Cliff or other steep rocky areas lacking vegetation
- B Sandy beach
- G Grassland, including pastures, fields, meadows, and savannah
- S Shrubland in relatively dry areas
- r Riparian vegetation or creek channel
- F Forest, trees closely spaced; non-riparian
- W Woodland, trees widely spaced; non-riparian
- A Aerial; associated with strong flying species often seen overhead

RELATIVE ABUNDANCE

- A Abundant; >100 individuals observed per day in appropriate habitat and season
- C Common; 10-100 individuals observed per day in appropriate habitat and season
- U Uncommon; <10 individuals observed per day in appropriate habitat and season
- R Rare; Observed every year but not seen daily in appropriate habitat and season
- Cs Casual; not observed every year, very unlikely to be seen
- X Extremely rare; < 5 records overall

Table 1 (continued).

SPECIES	SEASONAL STATUS	SPECIAL STATUS	PREFERRED HABITAT	RELATIVE ABUNDANCE	SUB-AREAS															
					AE	AM	AW	A	BE	BM	BW	B	CE	CM	CW	C	DE	DM	DW	D
Gadwall	W		FM,SM	R					X			X					X			X
Northern Pintail	W		FM,SM	U	X	X	X	X	X	X	X	X		X		X	X	X	X	X
Green-winged Teal	W		FM,SM	R	X	X	X	X	X	X	X	X	X	X		X	X		X	X
Cinnamon Teal	R*		FM	R										X		X	X			X
Blue-winged Teal	W		FM	X	X			X												
American Wigeon	W		OB,FM	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eurasian Wigeon	W		OB,FM	Cs							X	X					X			X
Northern Shoveler	W		FM	U	X	X	X	X	X	X		X					X			X
Redhead	W		OB,FM	R	X	X		X	X	X		X					X			X
Canvasback	W		FM	R	X			X	X	X		X					X			X
Ring-necked Duck	W		FM	R									X	X		X	X	X	X	X
Greater Scaup	W		OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lesser Scaup	W		OB,FM	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tufted Duck	W		OB,FM	X									X			X			X	X
Common Goldeneye	W		OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Barrow's Goldeneye	W	CSC,WL	OB	Cs	X			X	X		X	X	X	X	X	X	X			X
Bufflehead	W		OB,FM	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Harlequin Duck	W	FSC,CSC	OB,OC	Cs					X	X		X	X		X	X				
White-winged Scoter	W		OB	R	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Surf Scoter	W		OC,OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black Scoter	W		OB	C	X	X		X	X	X	X	X	X	X	X	X	X	X		X
Long-tailed Duck	W		OB	Cs			X	X		X	X	X	X	X	X	X	X	X	X	X
Ruddy Duck	W		OB,FM	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hooded Merganser	W		FM,r	Cs					X			X					X			X
Red-breasted Merganser	W		OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Common Merganser	W		r	R	X	X	X	X	X	X	X	X	X	X	X	X	X			X
King Eider	W		OC,OB	X				X												
Osprey	R*	CSC	OB	U	X		X	X	X	X	X	X			X	X	X	X	X	X
Bald Eagle	W	FT,SE	OB,FM	X					X		X	X				X	X			X
Northern Harrier	R*	CSC	G,SM,FM	U	X			X	X		X	X	X			X	X			X
Red-shourldered Hawk	LR*		r,F,W	U																
Red-tailed Hawk	LR*		G,W,A	U																
Peregrine Falcon	W		OB, M	U	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X
Peregrine Falcon (anatum)	W	FD,SE, MC	OB, M	X					X			X								
Prairie Falcon	W	CSC,WL	G	R					X			X								
Merlin	W	CSC	M,A	R					X			X					X		X	X
Common Moorhen	W*		FM	Cs													X			X
American Coot	W*		OB,FM	A	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X
Virginia Rail	W*		FM,SM	U															X	X
Sora	W		FM	R																X
California Clapper Rail	W*	FE,ST	SM	X															X	X
Black Rail	R*	ST,FSC,PIF	FM,SM	R															X	X
Yellow Rail	W	CSC,BMC,WL,PIF	FM,SM	X															X	X
Black-bellied Plover	W		M,A	C	X			X	X		X	X	X			X	X		X	X
American Golden-Plover	M		G	Cs	X			X												
Pacific Golden-Plover	W		G	Cs	X			X												
Golden-plover species	WM		G	R	X			X												
Western Snowy Plover	W	FT,CSC,BMC,PIF	B,M	U	X			X	X			X	X			X				
Semipalmated Plover	WM		M	C	X			X	X		X	X	X			X	X		X	X
Killdeer	R*		M,G	U	X			X	X		X	X	X			X	X		X	X
Black Oystercatcher	R*	PIF,WL	R	R						X	X	X								
American Avocet	W		M,SM	Cs	X			X	X			X					X		X	X
Greater Yellowlegs	W		M,SM	C	X			X	X		X	X	X			X	X		X	X
Lesser Yellowlegs	M		FM,SM	R	X			X			X	X	X			X	X		X	X
Willet	W		M,SM	A	X			X	X		X	X	X			X	X		X	X
Solitary Sandpiper	M		FM	X																X
Wandering Tattler	W		R	X					X			X	X			X				
Spotted Sandpiper	W		R	U	X			X	X		X	X	X			X			X	X
Whimbrel	W		M,B,SM	R	X			X	X		X	X	X			X			X	X
Long-billed Curlew	W	CSC,WL,BMC,PIF	M,SM	R	X			X	X			X	X			X			X	X
Marbled Godwit	W		M	A	X			X	X		X	X	X			X	X		X	X
Ruddy Turnstone	W		R	R	X			X	X		X	X	X			X				X
Black Turnstone	W		R	U	X			X	X		X	X	X			X	X		X	X
Surfbird	M		R	R	X			X	X			X	X			X				
Red Knot	M		B,M	R	X			X	X			X	X			X				X
Sanderling	W		B,M	A	X			X	X		X	X	X			X	X		X	X
Western Sandpiper	W		M	A	X			X	X		X	X	X			X	X		X	X

Table 1 (continued).

SPECIES	SEASONAL STATUS	SPECIAL STATUS	PREFERRED HABITAT	RELATIVE ABUNDANCE	SUB-AREAS														
					AE	AM	AW	A	BE	BM	BW	B	CE	CM	CW	C	DE	DM	DW	D
Semipalmated Sandpiper	M		M	X	X			X	X			X								
Stilt Sandpiper	M		M	X															X	X
Least Sandpiper	W		M	A	X			X	X		X	X	X			X	X		X	X
Baird's Sandpiper	M		FM,M	R	X			X	X			X	X			X				
Pectoral Sandpiper	M		FM	X					X			X								
Dunlin	W		M	A	X			X	X		X	X	X			X	X		X	X
Ruff	W		SM,FM	X					X			X								
Short-billed Dowitcher	M		M,SM	C	X			X	X		X	X	X			X			X	X
Long-billed Dowitcher	W		M,FM,SM	C	X			X	X			X	X			X			X	X
Dowitcher species	WM		M,FM,SM	C	X			X	X		X	X	X			X	X		X	X
Wilson's Snipe	W		G	U	X			X	X		X	X	X			X			X	X
Red-necked Phalarope	M		FM,OB	R	X			X	X			X	X			X	X		X	X
Red Phalarope	LM		OC, OB	Cs	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Parasitic Jaeger	M		OC,OB	U	X	X		X	X			X	X	X		X				
Franklin's Gull	M		B,M,OB	X						X		X	X			X				
Laughing Gull	M	CSC	B,M,OB	X									X			X				
Black-headed Gull	M		OB	X						X		X		X		X				
Little Gull	M		OB	X															X	X
Bonaparte's Gull	M		OB	R	X	X	X	X	X	X	X	X	X			X	X			X
Heermann's Gull	S		OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mew Gull	W		OB	U	X			X	X			X	X	X	X	X	X	X		X
Ring-billed Gull	R		B,M,OB	C	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
California Gull	W	CSC	B,M,OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Herring Gull	W		B,M,OB	U			X	X		X	X	X		X	X	X			X	X
Thayer's Gull	W		B,M,OB	R	X			X			X	X	X			X				
Western Gull	R*		B,M,OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Glaucous-winged Gull	W		B,M,OB	A	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Glaucous Gull	W		B,M,OB	X					X			X					X			X
Black-legged Kittiwake	LW		OC	X	X			X								X				
Caspian Tern	S		B,M,OB	C	X			X	X			X	X			X			X	X
Royal Tern	W		B,OB	X																
Elegant Tern	S	FSC,CSC,BMC	OB	C	X	X		X	X	X		X	X	X		X				
Common Tern	M		OB	Cs	X			X	X	X		X	X			X				
Arctic Tern	LM		OC	X	X			X												
Forster's Tern	R	WL	OB	U	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
California Least Tern	M	FE,SE,BMC	OB	X					X			X								
Black Tern	M	FSC,CSC,BMC	FM,SM,G	X																X
Black Skimmer	S	CSC,WL,BMC,PIF	OB	X					X			X								
Common Murre	LR		OC,OB	R			X	X	X	X		X	X	X	X	X			X	X
Pigeon Guillemot	LS		OC	X						X		X								
Marbled Murrelet	LR	FT,SE,BMC	OC	X				X												
Rhinoceros Auklet	LR	CSC	OC	X						X	X	X								
Cassin's Auklet	LR		OC	X											X	X				
Barn Owl	LR*		G,W,r	R					X			X								
Great-horned Owl	LR*	CSC,WL,BMC,PIF	G,W,r,F	R					X			X	X			X				
Short-eared Owl	W	FSC,CSC,WL,BMC	FM,SM,G	X					X			X								
Belted Kingfisher	R*		C,OB	U	X		X	X	X		X	X	X		X	X	X		X	X
Black Phoebe	R*		F,M,r	U									X			X				
American Crow	R*		G,r,W	C									X			X			X	X
Common Raven	R*		G,W	C	X			X	X			X	X		X	X	X		X	X
Horned Lark	W*	CSC	G	R	X			X												
Marsh Wren	R*		FM,SM	U									X			X			X	X
American Pipit	W		G,SM,FM,B	U	X			X	X			X	X			X				
Loggerhead Shrike	W	FSC,CSC,BMC,WL	G,W	X																X
Northern Shrike	W		G,W	X																X
Saltmarsh Common Yellowthroat	R*	FSC,CSC,	FM, SM	U							X	X	X		X	X			X	X
Savannah Sparrow	R		G,SM	C	X			X	X		X	X	X		X	X	X		X	X
Nelson's Sharp-tailed Sparrow	W		SM	X																X
Song Sparrow	R		r,FM,S	C	X			X	X		X	X	X		X	X	X		X	X
Swamp Sparrow	W		FM	R									X			X			X	X
Lincoln's Sparrow	W		S,r,G	U															X	X
Golden-crowned Sparrow	W		S,G	C	X			X	X			X	X			X			X	X
White-crowned Sparrow	R*		S,G	C	X			X	X			X	X			X			X	X
Western Meadowlark	W*		G,SM	U	X			X	X			X								X

Visiting investigators on ACR lands

The Other Scientific Agenda

by John P. Kelly

Research at Audubon Canyon Ranch may be more valuable than you think. As human impacts on nature continue to expand and intensify around us, visiting scientists at ACR recognize the increasing value of our sanctuaries as undisturbed, natural laboratories. Their investigations result in numerous contributions to ecological science, often with strong conservation applications, and their work provides us with sophisticated information about the ecology of our sanctuaries. Because of limits on the number of studies we can host without altering the natural character of our sanctuaries, we have been able to select from proposed projects the ones most likely to make a difference in conservation, locally as well as globally.

For example, the occurrence on ACR lands of Sudden Oak Death (SOD), a disease resulting from a newly described pathogenic organism, *Phytophthora ramorum*, provides a unique opportunity to study its effects on oak woodland ecosystems (see *Ardeid* 2002). At Bouverie Preserve and several other locations around the San Francisco Bay area, Don Dahlsten, Kyle Apigian, and David Rowney (UC Berkeley) are investigating SOD impacts on the nesting success, diet, foraging behavior, and habitat use of cavity-nesting birds. They are also using live traps to monitor the effects on small mammals, and cover boards to monitor reptiles and amphibians. Ultimately, they plan to collaborate with Barbara Allen-Diaz and Letty Brown (UC Berkeley), who will use vegetation data collected on the same plots to understand how SOD-induced changes in forest structure will affect the demography and functional responses of wildlife in California.

Cheryl Briggs, Martha Hoopes and John Latto (UC Berkeley) are studying metapopulations (groups of populations) of a gall-forming midge *(Rhopalomyia californica)* and a suite of parasitoid wasps that attack this midge. In particular, they are measuring the effects of dispersal and habitat structure in coyote brush *(Baccharis pilularis)* on the population dynamics of these species, with general implications about how species coexist. Dissections of more than 6,000 galls revealed outbreaks of midges to extremely high densities at Bolinas Lagoon Preserve (BLP). At Cypress Grove Preserve (CGP), parasitoid densities varied more from place to place and seemed to mimic midge densities better, allowing greater control.

As in most ecological investigations, numerous factors must be examined to assess the underlying processes affecting midge populations. Therefore, Vanessa Schmidt (UC Berkeley) and Martha Hoopes are further examining microenvironmental influences. By experimentally placing midges in mesh sleeves on

Continued on page 14

JEFF CORBIN

ACR lands provide natural laboratories where researchers from other institutions may conduct ecological field studies. Pictured here: Shelene Poetker (left) and Chris DiVittorio sample plants and count seeds in a study of coastal prairie at Toms Point (see pages 15–16).

Martha Hoopes, Cheryl Briggs, and John Latto (UC Berkeley) used tent-like exclosures in a study of insect populations at Bolinas Lagoon and Cypress Grove preserves, to examine the importance of dispersal and isolation in the persistence of fragmented populations.

JOHN KELLY

PETER LATOURRETTE

Swainson's Thrush (pictured) and Song Sparrow were the most frequent captures at the newly established MAPS station in Livermore Marsh.

branches in caged and uncaged environments, they found that season, plant quality (stem growth), and wind had large effects on successful gall and midge development. Currently, they are investigating these seasonal influences by setting up growth chambers to test the effects of temperature and water. Together, these studies of midge and parasitoid populations will test general principles used in the conservation of isolated populations of endangered species and in the control of ecological pests.

Conservation agencies commonly use habitat relationship models to determine whether areas proposed for increased human use are suitable for particular native species. Jennifer Shulzitski (USGS-Golden Gate Field Station) is conducting a regional study to test the ability of vegetation data and habitat maps to predict wildlife distributions, for use with existing wildlife habitat relationship models. She surveyed for mammals, amphibians, and reptiles within 15-meter, circular plots, using sooted track plates, Sherman live traps, pitfall traps, and cover boards. At BLP, she detected two species of amphibians and nine of mammals in habitat dominated by California bay laurel; one amphibian and nine mammals in coast live oak habitat; and one amphibian, one reptile, and eight mammals in coyote brush. During point counts to survey birds, she detected 35 species in California bay, 25 in coast live oak, and 31 in coyote brush.

In other bird research, longtime ACR volunteer Ken Burton initiated a bird-banding station this spring in Livermore Marsh at CGP. With the help of Denise Jones of The Institute for Bird Populations (IBP) and ACR's Michael Parkes, the station proved to be very productive, with 54 captures of 46 individuals of 13 species in six hours of operation. This station will be part of the Monitoring Avian Productivity and Survivorship (MAPS) Program coordinated by IBP. Data collected will be analyzed along with those from other MAPS stations in the region to monitor regional trends in adult population size, productivity, survivorship, and recruitment.

In coastal areas such as Tomales Bay and Bodega Harbor, eelgrass *(Zostera marina)* provides valuable ecosystem services, such as enhancing primary production, providing habitat for ecologically and economically important species, and buffering against erosion. Randall Hughes (UC Davis) is measuring genetic diversity, shoot density, epiphyte biomass, and invertebrate diversity in eelgrass at Cypress Grove Preserve and at eight other locations in Tomales Bay and Bodega Harbor. Using these data, he plans to evaluate the importance of genetic diversity to the ecosystem services eelgrass provides.

Tidelands and salt marshes

Land use practices such as grazing can substantially increase the input of nitrogen as runoff into estuaries. Bibit Traut (UC Davis) recently completed her PhD on the effects of nitrogen addition on the structure and dynamics of salt marsh vegetation in the Point Reyes area. In a field experiment at ACR's Walker Creek Marsh, she found that nitrogen addition did not result in the predicted increase in plant productivity and competitive exclusion of other species by salt grass *(Distichlis spicata)*. Instead, nitrogen addition led to greater overall biomass and tissue nitrogen, especially in *Triglochin concinna* and *Jaumea carnosa*.

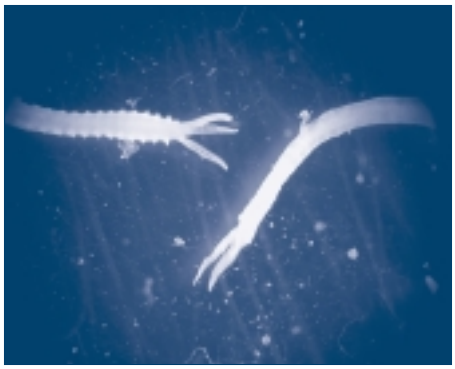
Plants can have important roles in regulating ecosystems. For example, some species can actively alter nutrient availability and species distributions. Understanding the roles of influential plants is essential if we are to predict the consequences of species losses or gains associated with human impacts or restoration efforts. At ACR's Toms Point, Brenda Grewel (UC Davis, currently at Univ. South Bohemia, Czech Republic) is studying the potentially important role of parasitic plants such as the rare, but locally abundant, Point Reyes bird's beak *(Cordylanthus maritimus* subsp. *palustris)*. Her research asks whether the parasite-host plant physiological link ameliorates stresses imposed by tidal inundation and salinity. Experimental results suggest that the parasite-host interaction modifies sediment (biogeochemical) conditions, improving aeration and salinity, and enhances community diversity.

JOHN P. KELLY

The rare, parasitic salt marsh plant, Point Reyes bird's beak, is the subject of two studies by visiting investigators on ACR's Tomales Bay properties.

The recovery of rare species often requires a detailed knowledge of the life history characteristics of target populations. Tod Wilms (UC Berkeley) may have found such important information in the rare salt marsh annual, Point Reyes bird's beak: certain populations of this species

Elizabeth Brusati (UC Davis) is measuring the responses of salt marsh invertebrates, such as the native amphipod, *Corophium* (left), and the introduced worm, *Streblospio benedicti* (right), to invasions by non-native cordgrass.



ELIZABETH BRUSATI

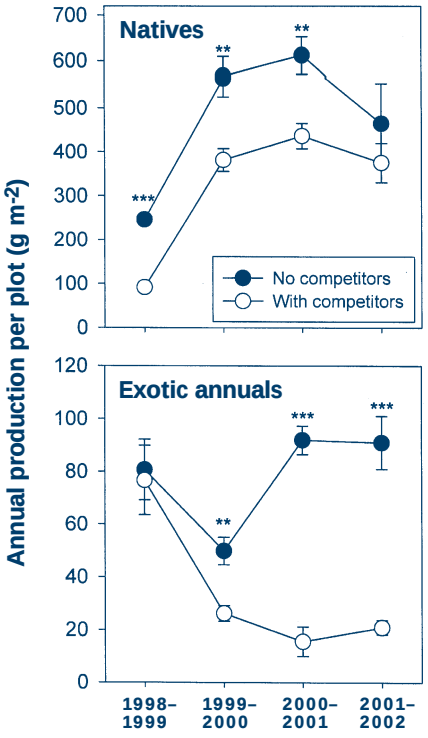


Figure 1. Mean productivity (± 1 SE) of native perennial bunchgrasses and exotic annual grasses from 1998-2002. Annual competitors reduced native growth in the first three years, but by the fourth year, annuals had no effect on natives. Asterisks indicate significant differences between "No competitor" and "With competitor" treatments.

JOHN P. KELLY

View of Giacomini Marsh from Railroad Point, near the mouth of Lagunitas Creek, where the National Park Service is initiating a monitoring program to measure changes resulting from the planned restoration of tidal wetlands.

may employ different reproductive modes. Two of the inner coastal populations maintain a floral structure with spatial separation between anthers and stigma. The outer coastal populations studied do not maintain this separation of female and male function, are apparently not visited by pollinators, and may reproduce entirely by "selfing." To understand these differences, Tod plans to examine the relationship between reproductive mode and genetic variation among these populations.

Invasions by influential, non-native species can have devastating consequences on native ecosystems. Elizabeth Brusati (UC Davis) is studying the macroinvertebrates in Pacific cordgrass *(Spartina foliosa)* marshes at ACR's Toms Point and Shields Marsh on Tomales Bay, and in San Francisco Bay marshes invaded by non-native East Coast cordgrass *(Spartina alterniflora)*. Understanding the invertebrates in these systems is important because they are the food for thousands of migratory shorebirds, and potential new invasions of non-native cordgrass threaten other West Coast estuaries. So far, Elizabeth has found higher densities of small invertebrates in Pacific cordgrass marshes than in the invaded marshes in San Francisco Bay. She is also conducting chemical analyses of invertebrates and plants to determine the relative importance of native cordgrass, pickleweed, and East Coast cordgrass to marsh food webs.

Ecological restoration and monitoring

The National Park Service is currently planning a wetlands restoration project for Giacomini Marsh, a large diked area at the southern end of Tomales Bay. Through reduction of contaminants, the project could augment other efforts to improve water quality in Tomales Bay, which has been declared "impaired" for sediment, nutrients, pathogens, and mercury by the San Francisco Regional Water Quality Control Board. Lorraine Parsons and her coworkers at the Point Reyes National Seashore are planning to conduct monitoring before and after restoration is implemented. A long-term monitoring program will begin in October 2003, but they have already initiated water quality monitoring in the project area and in selected reference wetlands, including ACR's Walker Creek Marsh.

Perhaps the most ambitious project on ACR lands is being conducted by the "Pacific Estuarine Ecosystem Indicator Research (PEEIR) Consortium." This multidisciplinary group, led by Susan Anderson, Steven Morgan, Gary Cherr, and Roger Nisbet (UC Bodega Marine Lab and UC Santa Barbara), includes 30 university scientists and non-profit partners from The Bay Institute and San Francisco Estuary Institute. Their goal is to develop a suite of ecological indicators to rapidly assess the integrity and sustainability of West Coast estuaries. The study sites, carefully selected in northern and southern California, include ACR's Walker Creek and Toms Point properties in Tomales Bay, Stege Marsh and China Camp in San Francisco Bay, Morro Bay, Carpinteria Marsh, and Mugu Lagoon. The indicators will measure impacts across levels of biological organization, trophic structure, life stage, time, and space. They are being developed by contrasting conditions at reference and impacted sites, and by following nutrient gradients at all sites and toxic contaminant gradients at three sites (Stege Marsh, Carpinteria Marsh, and Mugu Lagoon). For more information on this project, see http://www.bml.ucdavis.edu/peeir.

Coastal prairie

In their work at ACR's Toms Point on Tomales Bay, Jeffrey Corbin and Carla D'Antonio (UC Berkeley) have led a series of investigations on the ecology of coastal prairie ecosystems. In one study, they examined the competitiveness of non-native annual grasses to test whether the 19th-century introduction of exotic propagules into California grasslands was sufficient to shift community composition from native perennial to exotic annual grasses. They compared the aboveground productivity of native species

alone to native species competing with exotics, and exotic species alone to exotic species competing with natives. Over the course of the five-year experiment, native grasses have become increasingly dominant in the mixed-assemblage plots and have significantly reduced the productivity of exotic annual grasses since the second growing season (Figure 1). Given the relative competitiveness of the natives, it is unlikely that the introduction of exotic annual grass propagules alone, without changes in land use or climate, was sufficient to convert coastal prairie grasslands.

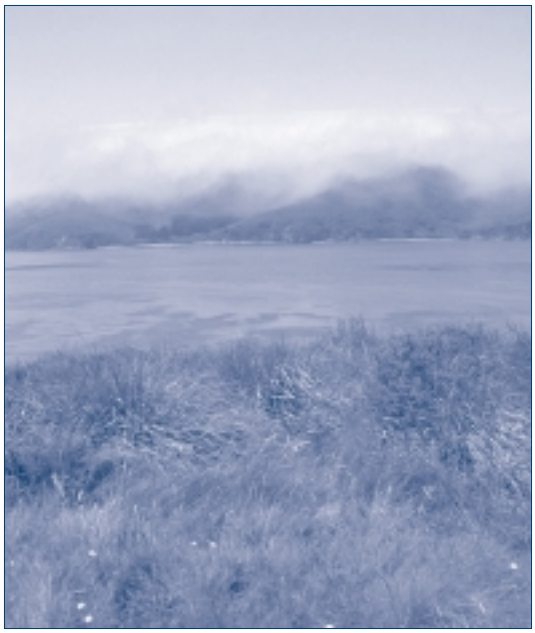
Sally Reynolds (UC Berkeley) collaborated with Jeff and Carla to examine the germination rates of native and exotic, annual and perennial grass seeds as a function of varying litter cover and temperature. Non-native species germinated at consistently higher rates than native species. Most non-natives tolerated a range of temperatures, and their rapid germination after wet-up may explain their expansive distribution throughout California. However, rapid germination may be only part of the story. Christopher DiVittorio (UC Berkeley) measured seed rain, seed banks, and colonization of artificial gopher mounds and determined that early flowering and a ubiquitous presence in soil seed banks may allow exotic species to usurp new sites quickly before native species can disperse.

In other experimental work, Jeff and Carla have found that nitrogen cycling rates are faster in coastal prairie plots dominated by non-native annual grasses than in plots dominated by either native or non-native perennial grasses. The annual-dominated plots were also less able to retain nitrogen. From this work, they have concluded that the invasion by exotic annual grasses, and subsequent invasion by exotic perennial grasses, have each influenced the cycling and retention of nitrogen in California grasslands.

During the last decade, coastal prairie habitats in northern California have suffered massive invasions by non-native perennial grasses. Using stable isotopes of hydrogen and oxygen, Jeff, Carla, Meredith Thomsen, and Todd Dawson (UC Berkeley) found that 16–66% of the water in perennial grasses during summer at Toms Point (and three other coastal sites) came from fog. Thus, the use of water from coastal fog may provide a competitive advantage to invasive perennial grasses.

One of the most abundant and widespread of California's native perennial bunchgrasses, *Nassella pulchra*, receives substantial water from coastal fog. However, inland *N. pulchra* populations are unlikely to receive any moisture during summer. Such differences may contribute to differences in root activity. Jeff used stable isotope analyses to determine that zones of water uptake at inland sites, at ACR's Bouverie Preserve and Jepson Prairie, were deeper than at Toms Point. He is planning to build on these results to determine whether differences in water use arise from local adaptation or, alternatively, phenotypic plasticity.

In other experiments at Toms Point, Tasha Teutsch, Monica Cundiff, Vannessa Schmidt, and Jeff Corbin (UC Berkeley) found that soil water was less available in "neighborhoods" invaded by exotic grasses than in pure native stands. But, surprisingly, native grasses were less water stressed when grown with exotics. These preliminary results suggest that the invasion of California grasslands has altered water availability as well as the water use strategies of native grasses.



JEFF CORBIN

Fog may be an important factor in the invasion of coastal prairie by non-native perennial grasses.

In 1999, Carla D'Antonio established permanent vegetation transects at Toms Point. Preliminary results from these transects suggest that ACR efforts to manually remove aggressive, non-native perennial grasses, such as orchard grass *(Dactylis glomeratus)* and velvet grass *(Holcus lanatus)*, are helping to maintain the native coastal prairie!

The ecosystem effects of changes in California's coastal grasslands are mostly unknown. However, Natalie Robinson (UC Berkeley) and Jeff Corbin are analyzing data from Toms Point that suggest higher diversity of arthropods (insects, spiders, and other invertebrates) in areas dominated by native and exotic perennial grasses than in areas dominated by exotic annual grasses. Much more work is needed to understand how coastal ecosystems are affected by changes in vegetation.

Natural areas in human landscapes

ACR's Bouverie Preserve is often used either as a natural control area in projects that include other sites or as a key component of the larger ecological landscape. These uses include studies on the health of riparian wetlands in the Sonoma Creek watershed, by Caitlin Cornwall and David Luther (Sonoma Ecology Center); bird communities in oak-vineyard landscapes, by Emily Heaton, Mark Reynolds, and Gretchen LeBuhn (UC Berkeley); effects of landscape change on native bees and pollination of native plants in Napa and Sonoma counties, by Gretchen LeBuhn (CSU San Francisco); impacts of butterfly gardens on pipevine swallowtail populations, by Jacqueline Levy (CSU San Francisco); and thermal monitoring in the Sonoma Creek watershed, by Wendy Losee (Sonoma Ecology Center).

Additional work on ACR's Tomales Bay properties include studies of environmental stressors and mortality of Pacific oysters, by Fred Griffin, Gary Cherr, and others (Bodega Marine Lab); a survey for the federally endangered tidewater goby *(Eucyclogobius newberryi)*, by Darren Fong (GGNRA); and surveys of Black Brant in Tomales Bay, Drakes Estero and Bodega Harbor, by Rod Hug (Santa Rosa).

It is exciting that so much research is going on at ACR. Visiting scientists not only help ACR to understand the living systems we protect, but they are making important contributions to conservation biology on a global scale. When combined with scientific contributions by ACR staff and collaborators, these projects illustrate the broad perspective on conservation needed to ensure the long-term health of our sanctuaries. ■

In progress: project updates

North Bay counties heron and egret project ◗ Annual monitoring of reproductive activities at all known heron and egret colonies in five northern Bay Area counties began in 1990. The data are used to examine regional patterns of reproductive performance, disturbance, habitat use, seasonal timing, and spatial relationships among heronries.

Picher Canyon heron and egret project ◗ The fates of all nesting attempts at ACR's Picher Canyon heronry are monitored, and reproductive success is analyzed annually. Field procedures are based on methods developed by Helen Pratt, who initiated the project in 1967 and published several papers on heron and egret nesting biology.

Livermore Marsh ◗ As ACR's Livermore Marsh transforms from a freshwater system into a tidal salt marsh, we are studying the relationship between increasing tidal prism and marsh channel topography. The results are being compared with data from mature reference marshes and will contribute to future restoration designs. The results will also contribute to studies of changing bird use and vegetation in the marsh.

Newt population study ◗ Annual newt surveys have been conducted along the Stuart Creek trail at Bouverie Preserve since 1987. The results track annual and intraseasonal abundance, and size/age and spatial distributions along the creek.

Shorebirds ◗ Since 1989, we have conducted annual bay-wide shorebird censuses on Tomales Bay. The data are used to investigate winter population patterns of shorebirds, local habitat values, and conservation implications. Other associated work has involves the effects of winter storms and food availability on energy balance and habitat use.

Tomales Bay waterbird survey ◗ Since 1989-90, teams of 12-15 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. Publications generated from this work highlight status and conservation concerns for waterbirds on Tomales Bay.

Predation by ravens in heron and egret colonies ◗ We are observing nesting ravens in Marin County and measuring their predatory behaviors at heron and egret nesting colonies, with an emphasis on heronries at ACR's Picher Canyon and Marin Islands National Wildlife Refuge. Radio telemetry and behavioral studies focus on evaluating home range variation, behaviors at heronries, and diurnal movement patterns. A road survey conducted throughout the San Francisco Bay area revealed concentrations of ravens in some urban/suburban areas and along the outer coast.

Plant species inventory ◗ Resident biologists maintain inventories of plant species known to occur at Bouverie and Bolinas Lagoon preserves. Grant Fletcher has established a database of shoreline plant species on Tomales Bay.

Annual *Cordylanthus* survey ◗ This project continues earlier field investigations on habitat and spatial relationships among patches of Point Reyes bird's beak, *Cordylanthus maritimus palustris,* in Tomales Bay marshes (Kelly and Fletcher 1994, Madrono 41: 316–327). The goal is to further address questions about long-term stability and biogeographic relationships among discrete patches on Tomales Bay.

Oak restoration ◗ Planting of native oaks at Bouverie Preserve was conducted with the help of school children. Annual monitoring involved measurements of oak sapling survivorship and vigor as well as breeding bird censuses (see *Ardeid* 2002).

Cape ivy control ◗ Work conducted by Len Blumin has proven that manual removal of non-native cape ivy can successfully restore riparian vegetation in ACR's Volunteer Canyon. Continued vigilance in weeded areas has been important, to combat resprouts of black nightshade, Vinca, and Japanese hedge parsley.

Eucalyptus removal at Bouverie and Bolinas Lagoon preserves ◗ Eucalyptus at Pike County Gulch of Bolinas Lagoon Preserve and along the Highway 12 border of Bouverie Preserve are being cut and removed with incremental annual efforts. Stumps and resprouts will be treated by methods developed in an associated investigation by Dan Gluesenkamp.

Eucalyptus resprout control ◗ An experiment is being conducted to determine the optimal method for controlling eucalyptus resprouts. Dan Gluesenkamp is testing the relative effectiveness of cutting, use of the herbicide Rodeo (glyphosate), and grinding stumps, to permanently kill cut eucalyptus trees in the lower field at Bouverie Preserve.

Bluebird boxes ◗ Tony Gilbert recently established Western Bluebird nest boxes at Cypress Grove Preserve. Soon after installation, a pair of Tree Swallows moved into one of the boxes. Tony is monitoring the boxes and plans to install additional boxes nearby, if necessary, to encourage their use by nesting bluebirds.

Wood Duck boxes ◗ In an effort to supplement Wood Duck habitat in west Marin, Rich Stallcup has established and monitors 40 nest boxes in the Olema Valley, including nine along Bear Valley Creek at ACR's Olema Marsh. These boxes have been fledging considerable numbers of Wood Ducks since 1998.

Experimental assessment of Wild Turkey impacts ◗ Dan Gluesenkamp is measuring the effects of foraging by non-native Wild Turkeys on vegetation structure and composition and the composition of invertebrates and herpetofauna at Bouverie Preserve. He is also measuring the consumption of specific food items by turkeys. Results will be used to evaluate ecological impacts of Wild Turkeys in forest ecosystems, and to substantiate efforts to control the impacts of introduced turkeys in western landscapes.

Annual surveys and removal of non-native cordgrass ◗ Katie Etienne is helping to coordinate annual surveys of tidelands in Tomales Bay, Drakes Estero, and Bolinas Lagoon to prevent invasion by non-native *Spartina* species (and their hybrids) with our native *Spartina foliosa*. The project is a collaboration with the San Francisco Invasive Spartina Project (California Coastal Conservancy), Point Reyes National Seashore, Golden Gate National Recreation Area, and local partners who share a commitment to proactive stewardship of natural areas in west Marin County (See *Ardeid* 2002).

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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Black-crowned Night-Herons are often the first species to flee when mixed heronries are disturbed by humans or predators.

GORDON SHERMAN

Marin Islands monitoring see page 1

Audubon Canyon Ranch
4900 Shoreline Hwy., Stinson Beach, CA 94970
Cypress Grove Research Center
P.O. Box 808
Marshall, CA 94940
(415) 663-8203

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