



Research and
Resource Management
at Audubon Canyon Ranch

THE ARDEID



- ▶ Heron and egret
nesting colonies
disturbance
patterns
- ▶ Invasive *Spartina*
marsh protection
- ▶ Acorns and
ecosystems oak
woodland
restoration
- ▶ A management
challenge raven
predation
- ▶ Sudden Oak Death
understanding
impacts

2002



In this issue

A Safe Place to Nest: Disturbance patterns in heronries **►** by *John P. Kelly*page 1

Invasive Spartina: The challenging changeling **►** by *Katie Etienne*.....page 4

Acorns and Ecosystems: Fourteen years of oak woodland restoration at the Bouverie Preserve **►** by *Rebecca Anderson-Jones*page 6

Resistible Forces? Raven predation in heronries **►** by *John P. Kelly*page 8

Sudden Oak Death Understanding the impact of a new epidemic on our forests and woodlands **►** by *Daniel Gluesenkamp*.....page 10

In Progress: Project updates **►**page 13

Cover photo: Great Blue Heron by Philip L. Greene **►** Ardeid masthead Great Blue Heron ink wash painting by Claudia Chapline

**Audubon Canyon Ranch
Research and Resource
Management**

Executive Staff

Skip Schwartz, *Executive Director*
John Petersen, *Associate Director*
Yvonne Pierce, *Administrative Director*

Staff Biologists

John Kelly, Ph.D., *Director; Research & Resource*

Management

Rebecca Anderson-Jones, *Bouverie Preserve*
Katie Etienne, *Research Coordinator*
Daniel Gluesenkamp, Ph.D., *Habitat Protection and*
Restoration Specialist

Gwen Heistand, *Bolinas Lagoon Preserve*

Land Stewards

Bill Arthur, *Bolinas Lagoon Preserve*
David Greene, *Tomales Bay properties*
John Martin, *Bouverie Preserve*

Field Biologists

Ellen Blustein
Nathan Farnau
Lauren Hammack
Mark McCaustland
Mari Ortwerth

Research Associates

Jules Evens
Grant Fletcher
Rachel Kamman
Flora Maclise
Helen Pratt
Rich Stallcup

Resource Management Associates

Len Blumin
Roberta Downey

Scientific Advisory Panel

Sarah Allen, Ph.D.
Peter Connors, Ph.D.
Jules Evens
Kent Julin, Ph.D.
Greg Kamman
Rachel Kamman
Chris Kjeldsen, Ph.D.
Doug Oman, Ph.D.
Helen Pratt
W. David Shuford
Rich Stallcup
Wesley W. Weathers, Ph.D.

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 in this list.

PROJECT CLASSIFICATIONS:

B = Breeding Bird Study at Bouverie Preserve **◆** C = Common Raven Study **◆**
H = Heron/Egret Project **◆** M = Livermore Marsh Monitoring **◆** N = Newt
Survey **◆** P = Photo Points **◆** R = Habitat Restoration **◆** S = Tomales Bay
Shorebird Project **◆** W = Tomales Bay Waterbird Census

Dawn Adams (HS); Sarah Allen (S); Jennie Anderson (H); Marie Anderson (R); Christina Attwood (R); Audubon Canyon Ranch - Bouverie Preserve Juniper Club (N); Autodesk employees (R); Bob Baez (SW); Norah Bain (H); Michele Baker (R); Sharon Bale (R); Melissa Banks (S); Tom Baty (W); Anne Baxter (H); Caitlin Bean (W); Gordon Bennett (S); J. Bjork (S); Louise Bielfelt (N); Gay Bishop (HS); Sara Blauman (H); Mike Blick (R); Julie Blumenthal (W); Len Blumin (R); Patti Blumin (HR); Ellen Blustein (M); Noelle Bon (HN); Janet Bosshard (HS); Phillip Bowman (R); Emily Brockman (HSW); Janet Bruno (R); Ken Burton (W); Denise Cadman (H); David Cain (R); Pam Cain (R); Barbara Carlson (N); Bill Carlson (N); Kate Carolan (S); Mike Caselli (R); Ann Cassidy (H); Dave Chalk (R); Roberta Chan (R); Marie Claire Chapman (R); Steve Cochrane (R); Carole Connell (H); Jaye Cook (S); Phil Cordle (R); Cynthia Corn (R); Helen Cravens (R); Catherine Cumberland (R); Rig Currie (S); Nancy Dakin (R); Karen Davis (H); Melissa Davis (HS); Nick Degenhardt (H); Nancy DeSousa (R); Carolyn Dixon (H); Roberta Downey (R); Joe Drennan (W); David Easton (H); April Eberhardt (R); Ronnie Estelle (S); Serge Etienne (HS); Cathy Evangelista (H); Jules Evens (SW); Nathan Farnau (HSW); Katie Fehring (SW); David Ferrera (W); Binny Fischer (H); Grant Fletcher (HPSW); Ginny Fletcher (HPS); Johina Forder (R); Carol Fraker (H); Jamie Freymuth (R); Audrey Fry (R); Randy Fry (R); Tony Gilbert (HSW); Keith Gish (H); Beryl Glitz (H); Dohn Glitz (H); Ellen Goldstone (N);) Brindy Greene (W); Phillip Greene (H); Lauren Hammack (M); Madelon Halpern (H); Diane Hichwa (BHS); Phillip Hughes (H); Jeri Jacobson (H); Gail Kabat (W); Lynnette Kahn (HS); Patty Karlin (H); Carol Keiper (SW); Marion Kirby (N); Richard Kirschman (SW); Ellen Krebs (H); Carol Kuelper (S); Alexis Lee (H); Laura Leek (W); Gail Lester (W); Keith Lester (W); Robin Leong (H); Eileen Libby (H); Eric Lichtwardt (HS); Flora Maclise

(H); Art Magill (R); Lyn Magill (R); Roger Marlowe (W); Chris Mc Auliffe (H); Pat Mclorie (N); Diane Merrill (H); Mike George (R); Frank Herrick (R); Hannah Hindley (R); Stuart Hindley (R); Nita Hon (R); Jim Hubbards (R); Leena Ilmarines (R); Barbara Janis (R); Rosemary Jepson (R); Art Magill (R); Lyn Magill (R); Roberta Maran (R); Sandy Martensen (R); Bill Masters (R); Diane McLure (R); JoAnne Meroney (R); Peter Meyerhof (R); Jean Miller (H); James Miramontez (R); Anne Murphy (H); Dan Murphy (W); Karen Nagle (BH); Wally Neville (H); Terry Nordbye (S); Gordon Nunnaly (R); John O' Connell (H); Brandon Orr (R); Julie Osborn-Shaw (R); Peggy Osterhamp (R); Mari Ortwerth (HS); Richard Panzer (H); Patagonia employees (R); Joelle Peebles (R); James Peebles (R); Kathy Peterlein (S); Myrlee Potosnak (H); Grace Pratt (N); Jorge Presser (S); Nancy Proctor (R); Clark Rector's Boy Scout Troop (R); Jeff Reichel (H); Linda Reichel (H); Jerry Ricard (R); Lucy Ricard (R); Robin Richard (R); Rudi Richardson (W); Cheryl Riley (H); John Risberg (R); Sally Risberg (R); Brian Roberts (R); Barbara Rosen (R); Glenda Ross (R); Liz Ruellan (R); Ellen Sabine (HS); Don Sanders (H); Marilyn Sanders (H); Fran Scarlett (H); Marie Schabroeck (R); Elisabeth Schlosser (R); John Sciochetti (R); Craig Scott (SW); Sierra Club "Outings" (R); Paul Skaj (W); Joe Smith (HW); Craig Solin (S); Betsy Spann (R); Anne Spencer (S); Rich Stallcup (S); Jean Starkweather (H); Elizabeth Stephens (S); Michael Stevenson (SW); Sandy Stoddard (R); Ron Storey (H); Grace Svitec (R); Cathleen Swanson (R); Lowell Sykes (HSW); Judy Temko (HS); Janet Thiessen (H); Gil Thomson (H); Dodie Thomson (H); James Titus (N); Sue Tredick (H); John Trott (R); Norma Vite (R); Tanis Walters (HS); Sarah Warnock (S); Sue Weingarten (R); Eric Eisenberg (R); Heather White (H); Rosilyn White (W); Tom White (W); Diane Williams (S); Phyllis Williams (H); Ken Wilson (HW); Jon Winter (H); Rollye Wiskerson (H); Angie Wolfow (H).

Disturbance patterns in heronries

A Safe Place to Nest

by John P. Kelly



PHILIP L. GREENE

An explosion of flapping wings breaks the quiet morning air at ACR's Picher Canyon. The herons ascend quickly into the air, circling, necks extended. Some land in nearby trees before gliding gradually back to their nest sites. Herons and egrets are most likely to exhibit fly-ups early in the nesting season, in apparent response to perceived danger but often with no obvious threat or stimulus. Because a safe place to nest is a fundamental requirement for successful breeding, the conservation of herons and egrets must consider potentially adverse effects of nesting disturbance. To what extent does human or other disturbance threaten heronries?

Nesting colonies of herons and egrets are spectacular in their beauty. They have attracted human interest for thousands of years, inspiring admiration as well as worldwide exploitation of their feathers for decoration and their eggs and young for food. Many heronries occur in close

proximity to people, and direct intrusion and indirect disturbance caused by human activities have resulted in adverse impacts on nesting.

Since 1990, ACR's regional Heron and Egret Project has documented many sources of disturbance to heronries across five northern counties of the San Francisco Bay area (Table 1). Any intense or repeated disturbance can cause birds to abandon a colony site permanently. However, it is not yet clear whether heronries are more strongly affected by human interference or by other sources of disturbance. To complicate the matter, the likelihood of disturbance by native or introduced nest predators may be enhanced or diminished by human activity or human alteration of habitats.

To avoid investigator disturbance, ACR observers at heronries follow these guidelines during field investigations: *Our first concern is for the birds. Be cautious. Watch for alert postures and listen for alarm calls*

Table 1. Types of human or other disturbances observed or inferred at northern San Francisco Bay area heronries, 1990-2001.

<i>Rainstorm</i>
<i>Windstorm</i>
<i>Power line interference</i>
<i>Building construction</i>
<i>Fence construction</i>
<i>Removal of nest tree(s)</i>
<i>Removal of nests</i>
<i>Tree trimming or chipping</i>
<i>Logging and tractor activity</i>
<i>Firecrackers</i>
<i>Army helicopter</i>
<i>Hot-air balloon</i>
<i>Spraying nests with garden hose</i>
<i>Reflective (Mylar) ribbons as deterrents</i>
<i>Shooting with 22 caliber rifle</i>
<i>Skeet shooting</i>
<i>Car doors slamming</i>
<i>Trucks in area</i>
<i>Interested human visitor</i>
<i>Incidental human activity</i>
<i>Investigator disturbance</i>
<i>Dog</i>
<i>Domestic or feral cat</i>
<i>Common Raven</i>
<i>American Crow</i>
<i>Red-tailed Hawk</i>
<i>Red-shouldered Hawk</i>
<i>Swainson's Hawk</i>
<i>Golden Eagle</i>
<i>Bald Eagle</i>
<i>Western Gull</i>
<i>Unknown owl</i>
<i>Osprey</i>
<i>Unknown avian predator</i>
<i>Non-native red fox</i>
<i>Raccoon</i>
<i>Unknown predator</i>

as you approach a colony, and retreat if there is any such suggestion of disturbance. Our best approach is to treat these beautiful birds with the cautious respect one should assume when encountering other cultures, nations, or worlds.

Continued on page 2

Testing disturbance thresholds

Several years ago, we measured the intraseasonal pattern of disturbance responses at 23 nesting colonies across the Bay Area. During each trial, an observer approached a colony on foot at a steady pace. We marked the position of the approaching person when the first heron exhibited alert behavior and also when the first heron flew from a nest site. We then measured the distance of each marked location from the colony. We repeated the trials at monthly intervals, but avoided the early courtship period when arriving birds are extremely sensitive to disturbance (respond at greater distances). Our results indicated that the responses of birds varied with stages in the nesting season (Figure 1).

A similar pattern of responses to other types of intrusions was found by Diana Vos and others (1985, *Colonial Waterbirds* 8: 13-22) of Colorado State University, although they did not interpret the apparent mid-season increases in sensitivity (Figure 2). Studies of different types of disturbance have shown consistently that heronries are less disturbed by approaching boats than by terrestrial intrusions (Rodgers and Smith 1995, *Conservations Biology* 9: 89-99).

Predicting the effects of disturbance at any given colony site, however, is not so

simple. The variability among sites is impressive (see 95% percentile ranges in Figure 1). At some sites, herons and egrets exhibit considerable tolerance to human activity and can be approached at close range—even by walking directly under nest trees—without exhibiting a disturbance response. In contrast, birds in other colonies will flee if humans approach within 200 m or more. These differences might partly reflect a capacity for habituation. Some investigators have even argued for systematically increasing human activity near colony sites to stimulate habituation and resilience to disturbance events (Nisbet 2000, *Waterbirds* 23: 312-332). However, habituation has not been adequately studied in herons and egrets. Therefore, its importance remains hypothetical and differences in tolerance to disturbances among heronries cannot be attributed clearly to habituation.

One pattern, however, has become clear. The reactions of breeding herons and egrets to disturbances depend strongly on the habitat structure of the colony. In our study, observers often approached incubating herons at close range in heronries with densely vegetated habitat without causing them to flush from their nests. The importance of dense vegetation as a barrier to disturbance has also been reported for herons along the upper Mississippi River (Thompson 1977,

Proc. Colonial Waterbird Group 1: 26-37), in Colorado (Vos et al. 1985), in Florida (Rodgers and Smith 1995), and in Europe (Hafner 2000, pp. 202-217 in Kushlan and Hafner, *Heron Conservation*,

Academic Press). Herons and egrets nesting in open habitat or in isolated trees tend to react earlier and more intensely to disturbance. However, this general pattern cannot reliably predict the sensitivity of particular colonies. Heronries in open and isolated patches of trees in Suisun Marsh and northern Sonoma and Napa counties vary substantially in their responses to approaching humans.

Buffer zones established to protect nesting herons and egrets from human activity are critical to the effective management of many heronries. Several scientific investigators have attempted to identify general rules of thumb for establishing buffer zones, based on disturbance distances such as those shown in Figures 1 and 2. In general, minimum recommended buffer zones of at least 200 m (based on behaviors exhibited in response to two approaching humans; Erwin 1989, *Colonial Waterbirds* 12: 104-108) agree well with our estimates in the Bay Area. Effective buffer zones should be based on upper 95th percentile of observed (standard normal) flushing distances plus 40-50 m because birds become agitated before intruders cause a response (Rodgers and Smith 1995), plus an additional 100 m to protect colony sites early in the nesting season when birds are first courting and establishing nest sites (Erwin 1989). Although such buffers seem to provide a conservative zone of protection, they remain arbitrary and fail to address differences in tolerance among colony sites.

Becky Carlson and Bruce McLean (1996, *Colonial Waterbirds* 19:124-127), of John Carroll University in Ohio, found

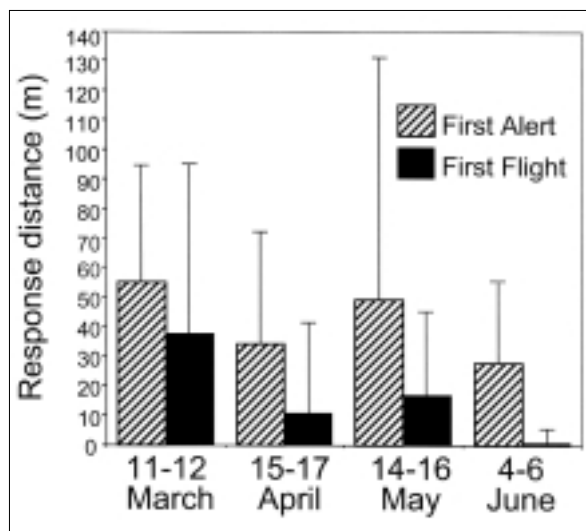


Figure 1. Average distance associated with responses of Great Blue Herons to an observer approaching on foot at 23 heronries in the San Francisco Bay area. Error bars indicate 95th percentiles of standard normal distances. Colonies are most easily disturbed when at least some individuals are still in the pre-laying/courtship phase (March). Birds become more site-tenacious as they settle into the incubation phase (March-April). As nestlings grow large and begin to thermoregulate, adults may temporarily flee or alter their behavior without significantly neglecting their young (May). Toward the end of the nesting season, adults are rarely present at their nests; nestlings are large and alert to closely approaching observers but unwilling to flee the safety of the nest (June).

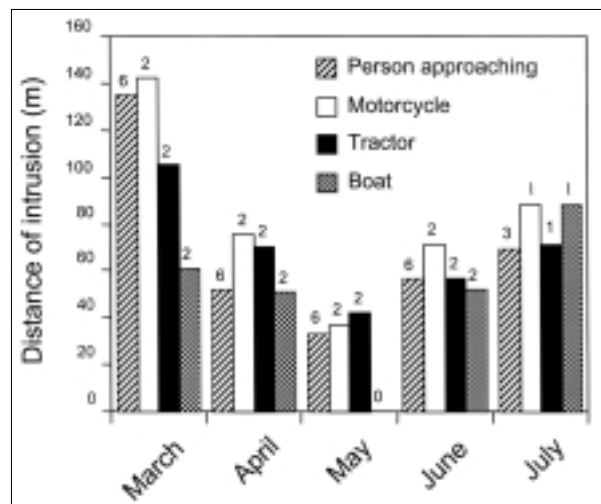


Figure 2. Average distance at which experimental intrusions caused two or more Great Blue Herons to fly from nests at Fossil Creek Reservoir, Colorado; adapted from Vos et al. (1985, *Colonial Waterbirds* 8:13-22). Number of trials is indicated above each bar.



that the type rather than the width of buffer zone was most strongly associated with nest success in Great Blue Herons. The most productive heronries were those that were isolated by moat-like water barriers or fencing, presumably providing protection from predators or human intruders, rather than those isolated simply by greater distances to human activity. So, occasionally, small areas near human activity can provide suitable nesting habitat if barriers to dis-

turbance are suitable. A good example of this can be seen at the Great Blue Heron colony on "Heron Island" in Stowe Lake, in San Francisco's busy Golden Gate Park.

Nevertheless, Bryan Watts and Dana Bradshaw (1994, *Colonial Waterbirds* 17:184-186), of the Center for Conservation Biology, College of William and Mary, Virginia, found that herons tend to establish colonies away from human activity (Figure 3). Their results seem convincing: potential disturbance

by humans influences the distribution of heronries. Will the undeveloped portions of our landscape remain adequate for the long-term needs of these birds?

Living with herons

Some heronries exhibit considerable tolerance to humans. Black-crowned Night-Herons, Little Egrets, and Chinese Pond Herons have nested undisturbed near a village near Hong Kong for over a century apparently because they were thought to bring good luck (Hafner 2000). In some parts of the world, herons have been respected and protected since ancient

times. A colony site in Vedanthangal, India, has been actively protected since 1790 (Hafner 2000). Herons and egrets have nested at ACR's Picher Canyon since at least 1941 and may have nested there for as long as 100 years (Pratt 1983, *Western Birds* 14:169-184). At other colony sites in our region where nesting herons or egrets are not disturbed when observed at close range, we have been pleased to encourage carefully managed educational opportunities for local residents.

In other cases, intense disturbance has resulted only in temporary responses without causing nest failure or colony site abandonment. Unfortunately, very few studies have actually measured the effects of disturbance on reproductive success or seasonal occupancy of colony sites. We have seen colony sites in the Bay Area abandoned after interference involving construction activities, tree trimming, and harassment by Golden Eagles, Common Ravens, and humans. In western Santa Rosa, a Snowy Egret and Black-crowned Night-Heron Colony moved four times in five years in response to intentional harassment by humans. To what extent does occasional disturbance affect the productivity of heronries in the Bay Area? We may soon have accumulated enough data to find out.

Disturbances once considered to be minor could become major. Recent population growth of ravens across the San Francisco Bay area, possibly related to urbanization and habitat alteration by humans (see Ardeid 2001), suggests regional increases in opportunistic nest predation. If so, adverse effects may become more likely after otherwise minor disturbances that temporarily flush adult herons and egrets from their nests.

Even the most careful management of heronries cannot guarantee their local stability. A fundamental characteristic of heron and egret colonies is that they shift locations over time, often in response to local disturbances. These shifts often result in the formation of "satellite" colonies close to or within a few kilometers of disturbed sites. Therefore, a regional management perspective may be crucial not only in protecting wetland feeding areas, but also in providing suitable alternative habitat for nesting near existing colony sites. Because these beautiful species depend widely on the landscapes in which we live, they remind us that conservation is a central challenge in managing our world. ■

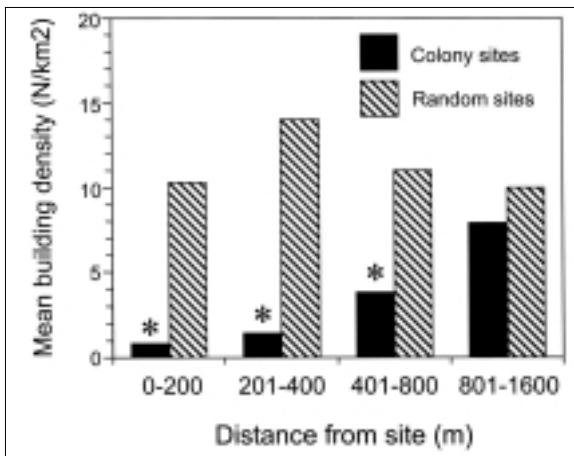


Figure 3. Average density of buildings at varying distances from 53 Great Blue Heron colony sites and at 58 random locations in the lower Chesapeake Bay, Virginia; adapted from Watts and Bradshaw (1994, *Colonial Waterbirds* 17:184-186). Areas are defined by non-overlapping concentric radii. *Asterisk indicates significant difference between colony and random locations ($P < 0.01$).

The challenging changeling

Invasive *Spartina*

by Katie Etienne

The invasion of non-native *Spartina* species (cord grass) represents one of the most alarming threats to coastal marsh systems. Although *Spartina* is a relatively new challenge for northern California (Figure 1), we must respond promptly to avoid the serious biological consequences that have accompanied *Spartina* invasions along the coasts of Britain, France, Washington State, and the San Francisco Estuary.

The introduction of non-native *Spartina alterniflora* to Washington State began in the 1870's, when trains and cargo ships used non-native cord grass for packing material. By the 1950's, *S. alterniflora* dominated 400 acres of tidal mudflats in Willapa Bay, according to local oyster growers. In 1995, following the discovery of two more non-native species (*S. anglica* and *S. patens*) and mounting evidence of biological and economic impacts, the Washington legislature declared the *Spartina* invasion an "environmental emergency." Private and public landholders reduced the size of some infestations by prioritizing projects and coordinating efforts. However, in 2001, over 5,000 acres of Washington tidelands had been invaded by non-native *Spartina* species, and recently *S. densiflora* was discovered in Gray's Harbor—the only coastal deep water port in Washington State.

This pattern of slow growth followed by rapid spread has also been observed in San Francisco Estuary. In 1975, *S. alterniflora* was imported from the Atlantic seaboard to prevent erosion and reclaim a marsh near Fremont, and transplants were used to restore the San Bruno Slough. By 1990, at least 650 circular patches of *S. alterniflora* were competing with the California native *S. foliosa* and other native plants (Callaway and Josselyn 1992, *Estuaries* 15: 218-26). A subsequent study revealed that most of



Spartina alterniflora.

these plants were actually hybrids of *S. alterniflora* and *S. foliosa* (Daehler and Strong (1997, *American Journal of Botany* 84: 607-611).

Ongoing research by Debra Ayres and colleagues at the UC Davis Bodega Marine Lab have refined a variety of molecular tools for identifying genetic differences between native and non-native *Spartina* and their hybrids. Their research shows that several generations of crossing have occurred and that some hybrids have variable morphology and greater reproductive vigor than either parent. The proliferation of these hybrids also reduces the probability that pollen from native plants will fertilize remnant populations of native *S. foliosa* (Ayres and Strong 2002, *Aquatic Nuisance Digest* 4: 37-39).

Being able to distinguish hybrids from parent species has also revealed that hybrids tolerate a wider range of conditions than either parent. The invasion of subtidal habitat by *S. alterniflora* and its hybrids is facilitated by the presence of aerenchyma tissue. The aerenchyma form tubes in the stem that increase oxygen transport to below-ground tissue which helps plants survive anoxic sediments,

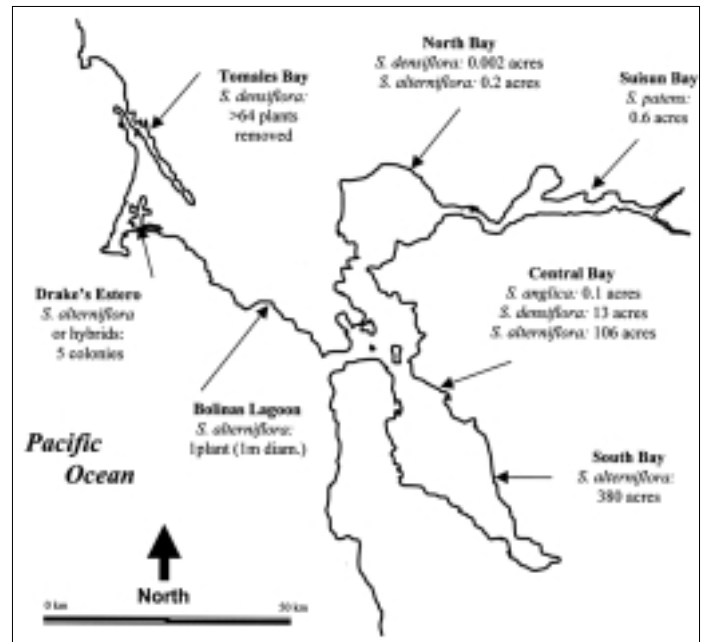


Figure 1. Distribution of introduced *Spartina* species 2000-2001. Data courtesy of Invasive *Spartina* Project <http://www.spartina.org>.

higher levels of hydrogen sulfide, and a wider range of salinity (Howes et al. 1986, *J. Ecology* 74:881-98).

Hybridization between native and non-native species can represent one of the greatest threats to ecosystems. For example, *S. alterniflora* and hybrids can modify the physical characteristics of marsh habitat and reduce tidal circulation. *Spartina* clones have a dense network of rhizomes that stabilize the soil. Above ground, the large stems grow closely together, which reduces the velocity of tide water and facilitates the deposition of sediment. In Willapa Bay, the diameter of the average clone increases by approximately 75 cm per year. If left uncontrolled, *Spartina* invasion has the potential to convert the salt marshes and open mud in San Francisco Bay into vast stands of hybrid and invader cord grass (Ayres and Strong 2002). Based on the mean tidal range of *S. alterniflora*, it is predicted that 65% of the mudflat in Bodega Bay could be covered if this vulnerable site were invaded by *S. alterniflora* or its

hybrids (Daehler and Strong 1996, Biological Conservation 78:51-58).

There are many serious consequences of transforming exposed mudflats into emergent marsh vegetation. Invasion by non-native *Spartina* species can adversely impact native plants and animals. Research in English marshes showed that the spread of *S. anglica* resulted in decreased shorebird abundance (Goss-Custard et al. 1995, J. Applied Ecology 32: 337-51), and competition with eel grass can reduce food for certain herbivorous waterbirds (Way 1991, Washington Sea Grant). In Willapa Bay, vast swards of *S. alterniflora* can restrict fish to narrow channels and limit access to open water except during periods when tide water rises above the non-native *Spartina*—which tends to grow taller than the native *S. foliosa* (Cordell et al. 1998, Proc. 8th International Zebra Mussel and Other Nuisance Species Conf., Sacramento).

The invasion of channel margins by non-native *S. densiflora* and its hybrids can restrict flow, cause widening of the flood plain, and reduce or eliminate foraging and nesting habitat for the federally and state endangered California Clapper Rail (*Rallus longirostris obsoletus*). At higher marsh zones, non-native *S. patens* grows in dense “cowlicks” and competes with native pickleweed (*Salicornia virginica*), which provides critical habitat for the salt marsh harvest mouse (*Reithrodontomys raviventris*). Other plants that do not compete well with *S. patens* are salt grass (*Distichlis spicata*) and the federally listed soft bird’s beak (*Cordylanthus mollis*).

What can we do to protect coastal marshes from invasion?

It is crucial to be on the look-out for invasive *Spartina*. However there are important reasons why we shouldn’t rush out and pull up suspicious plants. First, it can be difficult to identify both native and non-native plants, particularly early in the season, because there is considerable overlap in size and other field characteristics that can vary with local conditions. Please visit the Invasive *Spartina* Project web site (<http://www.spartina.org>) to download their excellent, full-color field identification guides. Second, it is extremely important that all plant material is removed, particularly seeds and root fragments. Finally, it is essential that we know where non-native plants have been discovered so these sites can be consistently monitored in the future.

An ounce of prevention is worth... much more than an extended period of Integrated Weed Management (IWM).

Posted on the Invasive *Spartina* Project (ISP) web site is an excellent summary of IWM methods, which demonstrate that the selection of appropriate methods depends on the scale of the problem. For example:

- Digging can be 100% effective for removing small, isolated clones, but every seed and portion of the rhizome must be removed. Because root material may extend 1.2 meters below the surface of the mudflat, this approach is not feasible when clones aggregate to form large patches or meadows.
- To contain a population or prevent hybridization, it is possible to control seed production by clipping seed heads to prevent pollination and seed dispersal. However, this requires constant attention because species flower over an extended period of time from April-December.
- To remove small-to-medium patches (up to 36 feet in diameter), all plant material must be completely covered with geo-textile fabric or plastic for two growing seasons.
- Mowing can control infestations of any size, except small seedlings. However, because mowing can initially invigorate the plant and promote root development, it must be repeated at least 4-6 times per year for a minimum of two growing seasons.
- Amphibious equipment has been developed for mechanical smothering and ripping of large infestations. This aggressive approach should be conducted during the fall or winter and is likely to degrade surrounding habitat or water quality.
- Herbicides are 0 to 100% effective, depending upon the conditions, timing and method of application and may have deleterious effects on non-target organisms. The use of aquatic pesticides currently requires a revocable-permit from the State Water Resources Control Board with extensive monitoring and reporting responsibilities.

Therefore, if you see a suspicious plant, please flag it and mark the location on a map. Report this information to Katy Zarembo, Field Biologist for the Invasive *Spartina* Project (ISP), at (510) 286-4091. If it is not possible to identify the plant in the field, it will be genetically tested. The exact location of all invasive *Spartina* plants will be recorded with a GPS unit so the site can be monitored for resprouts.

ISP was started two years ago by Debra Smith and others with support from the California Coastal Conservancy. The Project has an ambitious mission to study *Spartina* distributions, evaluate treatment methods, and develop management strategies to eliminate non-native *Spartina* in the San Francisco Estuary. The ISP team has also helped to monitor and control the first non-native *Spartina* discovered in coastal estuaries along the Marin County coastline (Figure 1).

The first *S. densiflora* plants in Tomales Bay were detected by Doug Spicher in 1999. Local monitoring began in 2001, when the ISP team assisted local property owners and biologists from Golden Gate National Recreation Area, Point Reyes National Seashore, and Audubon Canyon Ranch in surveying almost all of the

Tomales Bay shoreline. At the time, there were no genetic tests available to confirm the identification of 64 *S. densiflora* plants growing along the east shore of Tomales Bay, so we decided to carefully remove these plants based on their physical characteristics. *S. densiflora* tends to grow in dense tufts or mounds in the mid-to-high marsh zone, but we found these plants at the interface between open mud and marsh vegetation. *S. densiflora* usually flowers between April and July—earlier than *S. foliosa* which flowers between June and September.

In November 2001, a single clone of *S. alterniflora* was discovered at the north end of Bolinas Lagoon. Since then, five populations of *S. alterniflora* or hybrids have been discovered around Drakes Estero. Although many of these plants grew in round clones, some sparse seedlings were found growing in narrow bands that are characteristic of *S. foliosa* and did not have all of the field characteristics of the non-native. These variations in growth and morphology underscore the value of genetic identification and the importance of conducting thorough surveys each year. ■

Fourteen years of oak woodland restoration at the Bouverie Preserve

Acorns and Ecosystems

by Rebecca Anderson-Jones

For decades, land managers have noted declines in the regeneration of blue oak (*Quercus douglasii*) and valley oak (*Q. lobata*) throughout California. Some evidence suggests that woodland fragmentation may impair acorn production (see below). Woodland oaks also face crucial competition from introduced grasses. Oak woodland conservation can seem daunting! Success requires us to support acorn production and address recruitment challenges while bolstering the survival of mature trees.

Ecological challenges

Competition. Managing the land to enhance oak survival and regeneration is complicated by interactions between native oaks and introduced annual grasses. During the growing season, annual grasses are fierce competitors for light, water and nutrients near the surface, catching water before it percolates to deeper soil profiles where it can be used by native perennial grasses and mature oaks. By intercepting water, annual grasses compound the stresses affecting these magnificent trees. Ubiquitous grass competitors also create significant problems for oak seedling and sapling survival.

Regeneration. Early in his tenure with ACR, John Petersen, then Bouverie Preserve's Biologist, observed low rates of oak recruitment with concern, and conducted an age-class census in the preserve's mature oak woodland. Comparison of seedling numbers in his study area in spring and fall indicated a loss of nearly three-quarters over the four-month period corresponding with annual grazing to manage grass biomass. This is a familiar story in California's oak woodlands, with many ramifications.

Grazing animals can be a tremendous benefit in controlling the growth of annual grasses and reducing problems caused



Docent Maxine Hall and students Amanda Hall, Emily Davis, and Nathan Todhunter plant an oak at Bouverie Preserve.

by thatch build-up (e.g. declines in light and water penetration), but they can also have detrimental impacts on oaks. Cattle consume seedlings and—except in very small numbers—compact the soil. Alien weedy species and nitrogen enrichment are introduced to the system in their wastes. Cattle browse oak branches heavily and can break or crush saplings or top-ple enclosures intended to protect trees. Cattle also need free access to water throughout the grazing range to avoid overgrazing near existing water sources. Regular monitoring and careful management are needed to prevent or correct for these impacts. While other grazing animals or management techniques may be more suitable for alien grass control, each brings challenges that must be managed to limit adverse effects.

Habitat fragmentation. Lack of connectivity among woodlands may also contribute to the low regeneration of woodland oaks in California. Eric Knapp, Kevin Rice and Michael Goedde, from UC Davis, studied the role of tree density in wind-mediated pollen transfer in blue oaks. They found that pollen density correlated with distance from the source plant and

with acorn production (blue oaks). They inferred that blue oak regeneration should benefit when connectivity between trees is enhanced. This kind of connectivity is one of the tangible benefits of ACR's efforts to support habitat protection beyond the borders of our sanctuaries.

The oak planting project

Land managers use a variety of approaches to restore oak woodlands. In 1988, John Petersen took the direct route, working with Bouverie Preserve Fellow Bruce de Terra, dedicated volunteers, area children, and their teachers to implement an oak planting project. Their goal was to restore the lower field at Bouverie to the kind of plant community

likely to have existed before it was cleared for ranching more than a century earlier. This was a wonderful learning opportunity. It was also a hopeful beginning for what has become a long-term restoration project at the preserve.

Initially, the project was a straightforward attempt to mitigate for historic oak clearing, partially motivated by concerns about low levels of natural oak regeneration statewide. Since then, our restoration goals have changed subtly with our understanding of how they are affected by, and affect, the extensive vernal wetland system in the lowlands (to learn more about the vernal wetlands at Bouverie Preserve, see the 2001 Ardeid). Fourteen years after the oak planting project's inception, the restored oak woodland is showing early evidence of maturation that bodes well for the future.

What the data tell us

The oak planting project includes a two-part monitoring protocol. The first involves direct growth measurements. The second uses a breeding bird census to track the maturation of the woodlands as avian habitat, relative to mature oak woodland elsewhere on the

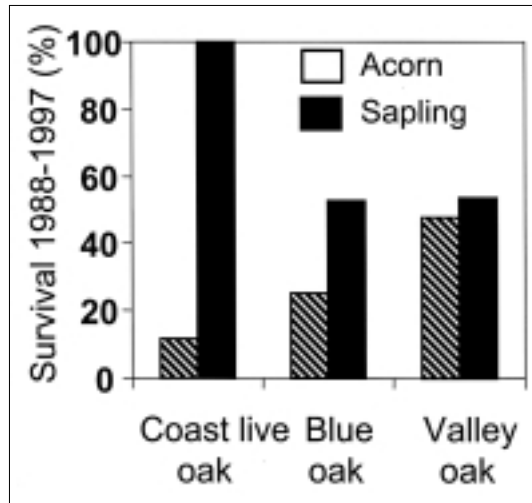


Figure 1. Survival of original oak stock nine years after planting. Note similar rates of sapling survival and relatively strong acorn survival in blue and valley oaks. Mortality of seedlings in all species and acorns in black oaks was 100%.

preserve. Despite problems with implementation of the monitoring program, we can draw some useful conclusions from our data.

Due to the unfortunate loss of location tags, 1997 was the last year growth data could be tracked to each tree's original source stock. Re-plantings were carefully documented, allowing us to track trees from the initial cohort through 1997. Oaks are known to have high mortality rates in the first years after planting or transplanting regardless of the type of propagules used. The *five-year* survivorship of oaks grown from acorns in our project is 25% for blue oaks and 47% for valley oaks. These rates are higher than *first-year* survival rates found by other researchers for valley oaks and only slightly lower than published first-year survival rates for blue oaks. When contrasted with published rates of survivorship after five years, our results are strong for both species. Trees initially planted as *saplings* showed high survivorship, with very similar data for valley and blue oak. (Figure 1). However, no trees planted as seedlings survived, and all black oaks (*Q. kelloggii*), planted only from acorns, died.

Despite lost tags, we were able to track a small number of trees from 1997 to 2002, and many of these have shown strong growth in stature or canopy development during this interval. Three coast live oaks increased 59, 62, and 98 cm in height, with trunk-to-dripline increases of 24, 41, and 51 cm respectively, while one valley oak increased in height by 138 cm with a trunk-to-dripline increase of 102 cm. Although we could not track growth

for most surviving trees beyond 1997, many have continued to thrive. Twenty-one trees of four species have grown above the livestock browse line (approx. 1.5 m), attaining a total height of 2m or greater, with nine of these greater than or equal to 3m in stature. Of these, three valley oaks stand at approximately 4m (Figure 2)!

Interestingly, while all plantings were of blue, coast live, black or valley oak species, three Oregon oak trees (*Quercus garryana*) currently thrive in the study area. Given the tendency of species in the white oak subgenus to hybridize and the lack of acorns to distinguish Oregon from valley oaks in this immature woodland, variability in leaf shape may have resulted

in misidentifications. However, field notes suggest a more compelling explanation. In 1997, a blue oak tree was noted to have significant branch die-back, showing only partial resprouting, while a smaller, healthy Oregon oak seedling grew within the same enclosure. At this time, the Oregon oak had reached 23 cm in height. By 2002, the Oregon oak had obtained a height of 70 cm, and the blue oak had died. The blue oak's death may have resulted from an intolerance of shade or other competition between the two trees, and its presence may have aided in the establishment of the more shade-tolerant Oregon oak. The site preparation and maintenance at that location almost certainly did. If Oregon oaks have been recruited from seed trees in nearby woodlands, as these observations suggest, the restoration project may be supplying other habitat values that support recruitment. For example, saplings in the restored woodland may provide roosts for birds, such as jays and woodpeckers, which are capable of distributing seed. Unassisted recruitment of oaks into the woodland is a sign of success, and an indicator that the system is maturing.

Breeding bird territories in the mature upper oak woodland were delineated and tallied annually from observations of singing males. This census was intended to provide a reference for comparison with breeding bird use of the lower, restored woodland. To date, our observations indicate that only Red-winged Blackbirds use the lower, restored woodland for breeding, although other species

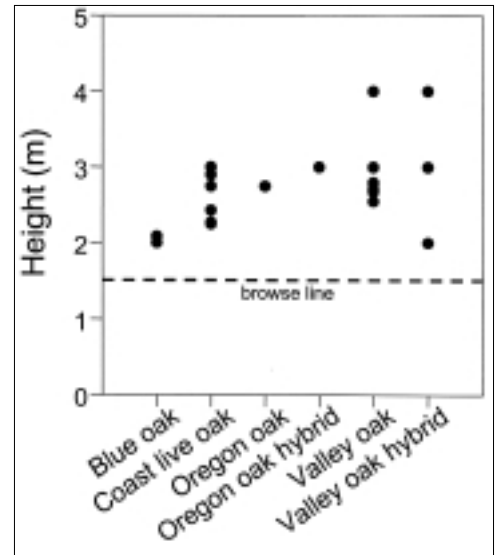


Figure 2. Twenty-one oak trees of four species (including trees showing evidence of hybridization with other species) show vigorous growth above the livestock browse line (1.5 m). Valley oaks are best represented among the taller trees.

are incidental visitors. Over time, we expect increased use of the restored woodland by oak woodland specialists and a decline in use by grassland birds, but continued use by wetland associates, such as the Red-winged Blackbirds.

What we learned and what we would do differently

Project results have helped us modify methods for use in future oak woodland restoration efforts. For example, future projects should track tree locations with GPS and mark *trees* rather than enclosures, prevent rodent damage with protective sleeves before trunks can be girdled, and include more rigorous weeding during the growing season. Nevertheless, we have evidence that the project has been successful. Although direct growth measurements are no longer the most useful indicators of success, they did help us track establishment of young trees. We will continue to monitor the maturation of the woodland as habitat for breeding birds and to manage the system to promote oak growth. The monitoring protocol is being revised to improve its usefulness as part of a long-term program for monitoring breeding birds across the Bouverie Preserve. The results will benefit other researchers interested in oak woodland management and restoration. The challenges of restoring whole ecosystems make this an exciting time to manage oak woodlands in California. ■

Raven predation in heronries

Resistible Forces?

by John P. Kelly

Managing wildlife is extremely difficult because natural processes that determine animal abundance and behavior are often complex and mysterious. Among the most mysterious are the influences of Common Ravens on nesting herons and egrets. Ravens occasionally prey on active heron and egret nests, but more typically they

are scavengers of failed nests and do not threaten the persistence of heronries. At most heronries, at least for now, managing the predatory activities of ravens is unnecessary. However, with raven populations growing rapidly in apparent response to the expansion of agriculture, roads, garbage dumps, and urbanization (see Ardeid



JOHN P. KELLY

Do ravens threaten heron and egret colonies?

For observers of heron and egret colonies, nest predation by Common Ravens can be a dramatic example of nature "red in tooth and claw." Ravens are expert egg predators, but their greatest threat to heronries seems to be in the predation of 3.5- to 5-week-old nestlings. This is the time in the nesting cycle when adult egrets begin to leave their nests unattended, as both parents forage for food needed by their developing young. At this point, nestlings may be grabbed and torn apart, then eaten or cached for later.

Contrary to popular impressions of serious threats from raven predation, preliminary results from ACR research indicate that nest predation by ravens is unlikely at most colony sites in the San Francisco Bay area—even though ravens may be near. However, resident ravens at some sites may specialize on egret eggs and nestlings for food during much or all of the nesting season. Good examples of such specialization occur in ravens nesting near the Picher Canyon heronry at ACR's Bolinas Lagoon Preserve and at Marin Islands National Wildlife Refuge near San Rafael.

In 1998, Great Egrets at Picher Canyon suffered severe nest predation by Common Ravens. Most nests were lost or abandoned, and only 26 young were successfully fledged, compared with expected production of 100-150 young. In subsequent years, ravens destroyed fewer nests, apparently because of reduced food demand associated with their own nesting failures. The ravens failed in 1999 and destroyed only as many as 9 (16%) of 58 Great Egret nests (we found direct evidence of raven predation at 5 nests). They failed again in 2000 and destroyed a maximum of 12 (21%) of 75 nests (direct evidence at 6 nests). In 2001, the ravens nested late but fledged 3 young and may have destroyed as many as 33 of 85 (39%) Great Egret nests (direct evidence at 8 nests). Egg predation at Picher Canyon has been relatively rare.

At West Marin Island, ravens have fledged 4-5 young each year since 1999. Estimates of Great Egret nest mortality, based on samples of individually monitored nests, were higher in 2001 (31%, n = 54 focal nests) than in 2000 (19%, n = 59) or 1999 (20%, n = 45). Great Egret nest mortality seemed to be lower in 2002 (12%, n = 68), although predation rates on Snowy Egret and Black-crowned Night-Heron nests were not measured. We quantified egg predation at Marin Islands based on the number of depredated heron and egret eggs found on East Marin Island where ravens nested. The results suggest a dramatic increase in egg predation in 2001 and a possible decline in 2002 (Table 1). The overall frequency of raven behaviors associated with the predation of heron or egret nests increased at Marin Islands and Picher Canyon through 2001 (Table 2) but was not measured in 2002.

Perhaps most alarming has been predation of adult Snowy Egrets indicated by carcasses found near raven roosts on East Marin Island: at least 4 adult Snowies were taken in 2000 (none found in prior years), at least 7 in 2001, and at least 15 in 2002! We are currently conducting a more rigorous analysis of trends in raven predation and survivorship of heron and egret nests at Marin Islands and Picher Canyon heronries. Whether these heronries can tolerate further increases in nest predation by ravens remains unknown.

2001), questions have emerged about potential increases in raven predation.

Resident ravens have become specialized nest predators at some regionally important heronries, such as Marin Islands National Wildlife Refuge near San Rafael and ACR's Picher Canyon heronry at Bolinas Lagoon Preserve (see box at left). If ensuring the persistence of particular nesting colonies depends on reducing raven predation, how might such a reduction be achieved? In a recent report to the California Department of Fish and Game (2001), Joseph Liebezeit and Luke George of Humboldt State University thoroughly reviewed methods for managing predation by ravens, but suitable strategies for controlling their effects on heronries remain unclear.

Conditioned Taste Aversion. In recent nesting seasons, we have attempted to establish "conditioned taste aversion" (CTA) in ravens at ACR's Picher Canyon. This involves providing chemically treated prey that can produce severe illness in ravens and, consequently, alter their predatory behavior (Nicolaus and Lee 1999, *Ecological Applications* 9(3): 1039-1049). By associating the taste of normal prey with acute illness, predators develop a reflex aversion for that taste. The aversion is then stimulated during subsequent predation attempts and ultimately alters their predatory behavior. If CTA could be established in territorial ravens at heronries, they might avoid egret nests while continuing to exclude other ravens from their territory—effectively "baby-sitting" the colony.

In 2001, we captured both of the resident ravens at Picher Canyon and provided each bird with a piece of meat from fallen Great Egret nestlings found dead under the heronry. The food was treated with enough fenthion to cause severe illness. Captive feeding helped ensure that

Table 1. Number of depredated eggs found on East Marin Island, 1999-2002.

Year	1999	2000	2001	2002
Search-days	8	3	6	4
Heron and egret eggs	45	16	140	79 ^b
Other eggs ^a	10	16	31	21 ^b
Total eggs	55	32	171	100 ^b

^a Other eggs include Western Gull and Mallard eggs.

^b Preliminary results as of 6 June.

the treated food was consumed completely by each individual, not shared with its mate or offspring, cached for later, or taken by other species. Captivity should not adversely affect the CTA process because the primary stimulus (taste) is transmitted directly through a medullar pathway, bypassing cognitive processes that later associate the response with other stimuli such as visual or location cues. When left alone (birds were observed through a remote video monitor), both ravens readily consumed the food ad libitum within 15-30 minutes. Before releasing the ravens, we mounted a radio transmitter to each of them so we could monitor their movements and behaviors. However, no subsequent behavioral changes were detected.

Because we were not able to develop a fully controlled experiment, we could not rule out the possibility of an error in CTA application or treatment dosage. We remain optimistic about the potential use of CTA as a management tool. The main problem is that ravens are very difficult to capture, often requiring two or more weeks of daily baiting and several additional days of trapping for each bird. Capturing individuals a second time at Picher Canyon could be even more difficult.

Disruption of nesting behavior. Nest predation at ACR's heronry on Bolinas Lagoon has been reduced in years when raven nesting attempts have failed. Therefore, preventing or delaying successful nesting by ravens might help in controlling nest predation. Potential methods of disrupting raven nesting behavior include the removal of nests or eggs, or treatment of eggs so they will not hatch. Addling (by shaking), oiling, or puncturing eggs to prevent hatching has the potential advantage of delaying the ravens' detection of nest failure, and thus delaying or preventing subsequent re-nesting. Disruption of successful nesting would require annual searches for nest locations and follow-up searches to locate

one or more re-nesting attempts each season. If ravens abandon an area after nest disturbance, a new nesting pair might establish a territory, or, in the absence of a new pair, vagrant groups of ravens might occupy the undefended heronry.

Repellents. Other options for controlling nest predation by ravens suggest little promise.

There is no consistent empirical support for the use of raven carcasses or models as effigies to deter raven activity. The use of visual, auditory, or chemical repellents to discourage raven predation is unlikely to succeed beyond an initial response period, and could disturb nesting herons and egrets.

Removal. Any removal of ravens would probably require an ongoing control program as other ravens move in to fill vacancies. If a new pair of resident ravens did not immediately fill the vacancy, vagrant non-territorial ravens might prey on heron and egret nests at equal or greater rates. Removing ravens from a colony site by any means presents considerable difficulties.

Translocation. Ravens cannot be translocated because of potential problems with disease transmission and exporting pest species to other areas.

Donation to education programs. Trapped individuals could be given to wildlife education programs, but such programs are not generally interested in such a commitment. Trapping may be very difficult (see below).

Trapping and euthanasia. Trapping followed by euthanasia may be the most feasible method of removal, but some ravens may be difficult to trap because of their cautious behavior or use of particular habitats. We found net launchers to be the most successful tool for trapping ravens, but as noted above, successful trapping may involve weeks of effort. It may be extremely difficult to trap both members of a nesting pair. Trapping both ravens at Picher Canyon may be even harder because they have already been captured once.

Shooting. Because ravens are extremely wary, they are very difficult to shoot. Shooting both members of a nesting pair

may not be possible. Shotguns require a close range, which is rarely available with ravens. Rifles allow a greater range but require greater accuracy and carry additional restrictions for safe use. Human activity in the vicinity of the ACR heronry would substantially limit safe firing angles and positions.

Poisoning. Removal by poisoning would require a major effort to prevent herons, Turkey Vultures, Scrub Jays, owls, and other native species from taking poisoned bait. Because ravens sample new food very cautiously, they might not be easily poisoned. The overriding issue, however, is that removal by any method would provide only temporary control as other ravens move in to fill vacancies.

At ACR, we have learned to appreciate the challenge of managing ravens in heronries. It is important to remember that ravens are native birds, protected by federal law, and have valuable ecological roles. Most options for managing ravens require special permits.

Table 2. Frequency of raven behaviors associated with mortality of heron or egret nests or nestlings at West Marin Island and Picher Canyon, 1999-2001. Behaviors include flying from the colony with eggs, young, or unidentified food, and perching in or adjacent to a failed nest.

Colony site	Number of nest predatory behaviors / 100 hrs		
	1999	2000	2001
West Marin Island	6.5	13.5	17.8
Picher Canyon	2.0	4.6	7.8
Both colony sites	3.1	6.9	10.8

Our best hope is that important heronries and, ultimately, heron and egret populations can tolerate increases in nest predation by ravens. This might be possible at Marin Islands, where several hundred heron and egret nests are susceptible to predation by a single pair of ravens. At Picher Canyon, nesting egrets have weathered moderate predation pressure during the last few years without serious consequences. However, the last time ravens at Picher Canyon raised a brood of at least four young (1998), their food demand peaked just as egret chicks became available. The devastating result (see box, page 8) suggests that a strategy for controlling raven predation may be necessary to avoid an annual game of "raven roulette" that risks future abandonment of the colony site. For now, however, the likelihood of successfully controlling raven predation remains unknown. ■

Understanding the impact of a new epidemic on our forests and woodlands

Sudden Oak Death

by Daniel Gluesenkamp



Left: Coast live oak tree in a fog-shrouded forest.

California was not always as it is today. Ten million years ago, warm winters and wet summers supported forests similar to those in eastern north America and China: maple, beech, ginkgos, rhododendron and sequoias. As the Sierra Nevada transformed from hills to mountains the climate changed dramatically. Rainfall decreased, summers became drier, and moisture-loving plants were pushed north into Oregon and beyond. Or they hid beneath oak trees.

Every naturalist knows that oak trees are important refugia, with deep taproots that draw water and nutrients 60 feet to the surface and a canopy that cools the weary botanist. Thousands of plant and animal species rely on oaks for habitat and food, and ten million years ago the oak trees that spread across the drying landscape provided shelter for Arcto-tertiary flora retreating northward. These refugees speciated into new forms and today are an important component of the flora we love; plants with northern affini-

ties (including *Dodecatheon*, *Delphinium*, and *Stipa*) make up about 49% of the species in our state. Most of these are found nowhere else in the world.

Today we see another transformation involving oaks, and this time the oak trees are in need of protection. Ancient oak trees are replaced by developments, acorns are failing to produce adult trees, and now a pathogen is sweeping through forests and woodlands like wildfire. This article summarizes current knowledge regarding Sudden Oak Death (SOD), discusses Audubon Canyon Ranch's response to the threat, and offers some suggestions for what we all can do to save the trees.

What is known about Sudden Oak Death?

Sudden oak death was first observed in 1995 by a Marin County extension agent who noted that oak trees were dying so rapidly they were dead before they could drop their leaves. Other common symptoms of SOD include dark sap bleeding from the trunk, the presence of

bark beetles, and "golf-ball" (*Hypoxylon* sp.) fungus on the trunk. Insects and fungi do not appear to cause SOD, but rather they opportunistically exploit dying trees and are a sign that the tree is already near death. Trees are most likely killed by a disease that creates large cankers in living trunk tissue, destroying conductive tissues and girdling the tree.

The disease agent is an oomycete (not a fungus) named *Phytophthora ramorum*; other *Phytophthora* species are responsible for Irish potato blight, avocado root-rot, and the near-

extinction of dozens of plant taxa in Australia. As is the case with other major American tree epidemics (including chestnut blight, Dutch elm disease, and Monterey pine pitch canker), *P. ramorum* is most likely an accidental introduction from Europe, with no evolutionary history in North America.

P. ramorum produces spores in the wet season that are dispersed in water, rain splash, and mud. *P. ramorum* is known to kill four oak species: coast live oak (*Quercus agrifolia*), black oak (*Q. kelloggii*), Shreve oak (*Q. parvula* var. *shrevei*), and tanoak (*Lithocarpus densiflorus*). Scrub oak, blue oak (*Q. douglassii*), valley oak (*Q. lobata*), and Oregon oak (*Q. garryana*) do not appear to contract the disease. Of the susceptible species, tanoak is most susceptible, and a high proportion of exposed trees develop the disease and die. Coast live oak is highly susceptible to infection, but inoculation experiments show that about 30% of infected trees may have some resistance to the disease

Table 1: Sudden Oak Death host list as of April 2002 (from the California Oak Mortality Task Force).

Common name	Scientific name
coast live oak	<i>Quercus agrifolia</i>
California black oak	<i>Quercus kelloggii</i>
Shreve oak	<i>Quercus parvula</i> var. <i>shrevei</i>
tanoak	<i>Lithocarpus densiflorus</i>
rhododendron	<i>Rhododendron</i> spp.
huckleberry	<i>Vaccinium ovatum</i>
California buckeye	<i>Aesculus californica</i>
Pacific madrone	<i>Arbutus menziesii</i>
manzanita	<i>Arctostaphylos manzanita</i>
bay laurel	<i>Umbellularia californica</i>
California coffeeberry	<i>Rhamnus californica</i>
toyon	<i>Heteromeles arbutifolia</i>
California honeysuckle	<i>Lonicera hispidula</i>
bigleaf maple	<i>Acer macrophyllum</i>
viburnum	<i>Viburnum bodnantense</i>

(Rizzo et. al., 2001, Fifth Symposium on Oak Woodlands).

Improved detection techniques have revealed *P. ramorum* infection in several additional host plant species (Table 1), and the list continues to grow. While most of these alternate hosts are not severely affected (huckleberry, madrone, and rhododendron may be killed), they are important to the spread and persistence of the disease. For example, bay laurel trees probably act as "Typhoid Mary" in our hardwood forests. Bay trees are almost unaffected by the disease but produce copious quantities of *P. ramorum* spores. In contrast, oak species that are killed by the pathogen often fail to produce spores even in laboratory cultures. Thus, bay trees that are unaffected by the disease produce spores that infect and kill oaks; this is shown by recent research showing that oaks growing near bay trees are more likely to be infected than are oaks growing



Species not known to be affected by Sudden Oak Death include blue oak (left) and valley oak (right).

without bay neighbors (Swiecke and Berndhart, 2001, Fifth Symposium on Oak Woodlands). Since these two species may compete for light and other resources, production of oak-killing spores by bay laurel can be considered a form of biological warfare between bays and oaks! This curious relationship has important ramifications: since spores are coming from resistant host species, it is unlikely that coevolution of the oak-pathogen interaction will reduce virulence of the pathogen. Plans for combating the disease must include these alternate hosts.

It is unlikely that

we will find a cure for Sudden Oak Death. Some chemical treatments may reduce rates of infection and extend the life of infected individuals (Garbeletto et. al., 2001, Fifth Symposium on Oak Woodlands), but the expense and potential for negative side effects preclude application to wildlands. Since there are no means for treating infected forests, its important that we map the disease and reduce its rate of

spread (see below). In particular, experiments with seedlings suggest that northern red oak (*Q. rubra*) and pin oak (*Q. palustris*) may be highly sensitive to the pathogen (D. Rizzo, 2001, Western International Forest Disease Work Conference), and dispersal of *P. ramorum* to midwestern and eastern oak forests could have terrible consequences.



Among the vulnerable species: coast live oak (left) and tanoak (above).

Sudden Oak Death and Audubon Canyon Ranch

Sudden Oak Death has not yet been detected at ACR's coastal Marin preserves, and we continue to monitor these sites. The disease is present at the Bouverie Preserve and has been cultured by J. Davidson (U.C. Davis) and S. Swain (Sonoma County) from coast live oak and bay laurels at several locations. Symptoms of *Phytophthora* infection appear on bay leaves in many parts of the preserve, and the pathogen is likely present in most of BP's coast live oak stands. Dead and dying live oaks with symptoms of SOD are particularly abundant along the length of the Loop Trail leading up to the bark house.

Sudden Oak Death is expected to significantly affect Bouverie's coast live oaks, and black oaks and madrone may also be killed. Assessing the scale of the problem is complicated by the notable tree diversity of the Bouverie Preserve, with nine oak species. It is important to collect data that will reveal patterns obscured by the visual complexity of our diverse hardwood forests. Current and planned work at the Bouverie Preserve focuses on mapping the distribution of diseased trees and censusing forests to quantify species composition, age structure, and health of trees. In addition to addressing SOD concerns, this work will provide valuable baseline data to inform future management of our forests.

We are also cooperating with other researchers and agencies to understand the distribution and ecology of this new disease. In the last two years, we have

Continued on page 12

What you can do to fight Sudden Oak Death

1) Do not transport infected plant material

State regulations currently restrict movement of known hosts or soil from or within infected areas. Oregon, Canada, and South Korea have established quarantines on host plant material from California, and the U.S. Department of Agriculture has imposed an interim quarantine while regulations are finalized. These rules reflect common sense: material that may be infected (including soil and branches, leaves, or wood, from any of the known host species) should not be moved. Dead or dying trees should be left in place unless they present a safety hazard and, if trimmed, material should remain on site. Bay laurel wreaths and oak, bay, and madrone firewood should not be moved into uninfected areas.

2) Lovers of the natural world must use protection.

Spores are easily transported by humans, and so Sudden Oak Death is most prevalent at sites with high public visitation. After leaving an area known to be infected, wash mud from shoes, bicycle tires, horses, and vehicles; this simple action also slows the spread of other problematic non-native species. Muddy cars should be run through a carwash on the drive home. Tree work or vegetation management should be done in the dry summer months, when abundance of *Phytophthora* spores is lowest, and tools should be sanitized after each tree. Potential vectors can be sanitized using Lysol or a solution of 1 part bleach to 9 parts water.

3) Keep your oak trees healthy

If you have oaks growing around your home or business, you can protect them from disease. When marveling at a giant oak canopy, remember that most of the tree is below ground. These large root systems are very sensitive. Do not pave, disturb, or compact within the drip line (outline of branches); if possible, pamper the root zone with 4-6 inches of mulch – but NOT bay laurel mulch! California oaks evolved with dry summer conditions and cannot tolerate wet roots year round. Do not water oak trees during the summer, and avoid planting lush landscaping adjacent to mature oaks. Potential *Phytophthora* hosts (Table 1) should not be planted near oaks.

4) Support increased protection for oaks in California.

The greatest current threat to California oaks is clearing of oaks for urban development and agriculture. Groups such as the California Oak Foundation are working to protect oaks statewide, and many local groups contribute to local oak protection ordinances. This work has added significance in light of the rapidly spreading epidemic: the oak that you save today may be great-grandfather to the *Phytophthora*-resistant forests of tomorrow.

5) Stay informed

Our understanding of this epidemic is improving rapidly. Sudden Oak Death was first observed in 1995, the causal agent was identified as a species of *Phytophthora* in 2000, and the species was isolated and named in 2001. The list of *P. ramorum* hosts has tripled in the last year, and the first scientific paper on *P. ramorum* was published in 2002. While the popular media have done a fantastic job of covering this subject, recent coverage has favored the sensational over the factual. Fortunately, current state of the science can be found on several websites maintained by researchers and managers:

The California Oak Mortality Task Force: <http://suddenoakdeath.org>

The UC Marin County Cooperative Extension: <http://cemarlin.ucdavis.edu/index2.html>

The California Oak Foundation: <http://www.californiaoaks.org>

seen field visits and tissue collection by researchers from UC Davis and by the Sonoma County Sudden Oak Death Coordinator. In addition to assisting regional studies of this disease, these visits have helped ACR staff to identify and assess SOD at the BP. We look forward to continued participation by cooperating investigators.

ACR staff are working to develop protocols to slow the spread of *P. ramorum* among sites and within preserves. Options include establishing hygiene protocols in rainy season, including sterilizing boots before entering and leaving the preserve, and even closing specific trails that are probable sources of infective spores. Fortunately, hygiene measures

can be applied seasonally, since risk from *P. ramorum* spores is greatest during the wet season. We are re-evaluating methods used in oak woodland restoration projects; one approach might include greenhouse inoculation of seedlings with *P. ramorum* to screen out susceptible genotypes. This would reduce transplant mortality in the field, hasten development of SOD-resistant forests, and provide valuable data regarding the frequency of disease resistance in our oaks.

Finally, ACR is contributing to the battle against Sudden Oak Death by maintaining sanctuaries where biological processes can occur uninterrupted. Since it is unlikely that we will find a cure for Sudden Oak Death, persistence of oak

forests requires an equilibrium between disease and host. This could occur through selection for resistant trees, selection for less virulent pathogen genotypes, or regulation of the pathogen by other components of the community. By leaving sick trees in place we allow partially resistant trees the opportunity to resprout, allow the less virulent *P. ramorum* strains to persist, and provide habitat for birds, fungi, insects, and oomycota that may contribute to a new stable equilibrium. In a world where more oaks are killed by development than by disease, preservation of natural oak forests and woodlands is an important mission. ■

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 involved 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. Baseline status and conservation concerns for waterbirds have been evaluated and published (Kelly and Tappen 1998, *Western Birds*).

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

article by Rebecca Anderson-Jones, page 6).

Cape ivy control ▶ Work conducted by Len Blumin has proven that manual removal of nonnative 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 from Pike County Gulch at 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 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.

Visiting investigators

Elizabeth Brusati (UC Davis), *Consequences of species invasion under global climate change.*

Yvonne Chan and Peter Arcese (University of Wisconsin), *Subspecific differentiation and genetic population structure of Song Sparrows in the San Francisco Bay area.*

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

Caitlin Cornwall (Sonoma Ecology Center), *Community based assessment of biological health of riparian wetlands in the Sonoma Creek watershed.*

Elizabeth Dahm (Sonoma State University), *Larval amphibian survey of vernal wetlands.*

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

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

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

Emily Heaton (UC Berkeley), *Bird communities in north coast oak-vineyard landscapes.*

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

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

W. Joe Jones (UC Santa Cruz), *Population structure of the California roach.*

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

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

Wendy Losee (Sonoma Ecology Center), *Thermal monitoring, Sonoma Creek watershed assessment.*

Steven Morgan, Susan Anderson, and others (UC Davis Bodega Marine Lab, UC Santa Barbara), *Ecological indicators in west coast estuaries.*

Lorraine Parsons (Point Reyes National Seashore), *Long-term water quality monitoring, Walker Creek and Giacomini Wetland.*

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

Bibit Traut (UC Davis), *Structure and function of coastal high-saltmarsh ecotones.* ■



THE ARDEID

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

The Ardeid is published annually by Audubon Canyon Ranch as an offering to 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. ©2002 Audubon Canyon Ranch. Printed on recycled paper.

Managing Editor, John Kelly. Layout design by Claire Peaslee.

Research
and Resource
Management at
Audubon Canyon Ranch

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

BOLINAS LAGOON PRESERVE • CYPRESS GROVE RESEARCH CENTER • BOUVERIE PRESERVE

Oak forest canopy see pages 6 and 10



DANIEL GLUESENKAMP

Audubon Canyon Ranch, 4900 Shoreline Hwy., Stinson Beach, CA 94970

Cypress Grove Research Center
P.O. Box 808
Marshall, CA 94940
(415) 663-8203

Nonprofit Org.
U.S. Postage
PAID
Permit No. 2
Stinson Beach, CA