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A NATIONAL REVIEW OF THE STATUS OF TRAPPING FOR BIRD CONTROL

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ABSTRACT: We examined the status of trapping to control bird damage based on a nation-wide questionnaire, literature, and on-site visits of trapping programs. We mailed 464 questionnaires to Agriculture Commissioners in California, Cooperative Extension Wildlife Specialists, USDA APHIS Wildlife Services personnel, state Department of Agriculture personnel, and members of the National Animal Damage Control Association. Two hundred fifty questionnaires (54%) were returned from 50 states, 1 territory, and 51 California counties. Fifty-four percent of the respondents indicated they either trap, monitor, or provide information on bird trapping. Regarding specific activities, 49% actively trapped while 43% provided information only. By affiliation, 90% of private respondents trapped, followed by 60% of federal respondents. Respondents listed 53 species of birds causing damage. Cited most often were rock doves (*Columba livia*), European starlings (*Sturnus vulgaris*), blackbirds, Canada geese (*Branta canadensis*), American crows (*Corvus brachyrhynchos*), house finch (*Carpodacus mexicanus*), and house sparrows (*Passer domesticus*). Respondents listed 52 crops, 18 types of animal production facilities, and 16 non-crop sites that were subject to bird damage. Respondents listed 25 species that were trapped. Modified Australian crow traps, walk-in traps, and drive traps were used most frequently. Most respondents (80%) rated trapping as moderate to excellent for ducks, geese, rock doves, and house sparrows. Trapping for starlings was rated as moderate to excellent by 75% of private-industry respondents (mostly non-agricultural damage), but 80% of California county returns (dealing mostly with agricultural damage) rated it as slight. Differences in control ratings for some species related to the type of damage site, geographic location, and organizational affiliation. Most (57%) respondents felt trapping was not important in overall bird control in any crop. California Agriculture Commissioners (>70%), however, indicated trapping was important for starling and house finch control, particularly in grapes. Most respondents (71%) felt trapping for bird control stayed at the same level or increased since 1990, and 82% thought it would stay the same or increase in the future. This sentiment was strongest among respondents from private industry (93%).

We identified literature on general trapping concepts, specific traps, trapping techniques, and operational trapping programs. We found no rigorous evaluations of trapping's effectiveness or the factors influencing results. Three studies provided partial economic analyses, but most evaluations of trapping put emphasis on the numbers of birds caught rather than the amount of damage eliminated in relation to the cost of control. New trap designs or trapping strategies that may have application to current bird problems include the impact trap, the Modesto funnel trap, noose-covered wickets, glue-coated perches, decoy-crop trapping, trammel nets, and mist nets.

We identified five California counties currently monitoring house finch trapping. From 1991 to 1995, an average of nearly 100,000 house finch have been trapped annually. Only Sonoma County currently traps with county personnel, taking an average of 1,000 starlings/year from 1991 to 1995.

We conclude trapping for bird control: 1) is commonly used across the country by a broad segment of wildlife damage control practitioners; 2) is important for the control of selected species, such as starlings and house finch in California; 3) is important for bird control in certain crops such as grapes in California, and non-crop sites such as around buildings in urban areas; 4) will continue to be used at the same or increased levels in the future; 5) has not been rigorously evaluated from a cost-benefit standpoint; 6) can be improved with new trap designs and strategies; and 7) merits additional research.

KEY WORDS: agriculture, bird control, bird trapping, damage, questionnaire

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INTRODUCTION

A variety of birds, including finches, blackbirds, starlings, horned flarks, and crows, damage many crops in California (Clark 1994). Row crops, nut and fruit crops such as grapes, seedling stands of sugar beets, tomatoes, and lettuce can suffer significant losses. Most growers attempt to alleviate damage by shooting and frightening birds. However, grower surveys have consistently shown dissatisfaction with these control techniques (e.g., Hasey and Salmon 1993; Marcum and Gorenzel 1994; Salmon et al. 1986). In addition, the problem has probably worsened for some growers with the loss of control materials (e.g., strychnine in 1989).

Given the general dissatisfaction with scaring techniques, the loss of toxicants, and the low probability of any revolutionary bird control techniques, a review of the status, use, and potential of existing techniques is warranted. In particular, the loss of strychnine for bird control has placed greater importance on bird trapping to alleviate agricultural damage.

The objective of this study is to describe the status of trapping to control bird damage based on a nation-wide questionnaire and a literature review. Particular subjects of interest include: 1) species causing damage; 2) target species (species capable of being trapped); 3) crops or sites damaged; 4) specific management practices (e.g., traps used, baits, timing, trap placement); 5) reduction of damage by trapping; 6) future outlook for bird trapping; 7) new trap designs or trapping strategies; 8) the status and potential of bird trapping in California; and 9) research needs.

METHODS

Questionnaire

We designed a three-page questionnaire and assembled a mailing list of individuals with federal, state, county, university, or private industry affiliations. The mailing list included all County Agriculture Commissioners in California, all Cooperative Extension Wildlife Specialists in the United States and various territories dealing with animal damage control, all state directors of USDA APHIS Wildlife Services, heads of the Department of Agriculture for every state, and all members of the National Animal Damage Control Association (NADCA). NADCA includes nuisance wildlife control operators (NWCOs), pest control operators, and growers. The latter three groups provided a private-enterprise perspective of trapping and expanded the scope of the survey to include nuisance birds. We mailed the questionnaires and a cover letter in late October 1996. We sent a follow-up mailing to non-respondents in late December 1996 and early January 1997.

Literature Review

We searched online databases of the University of California library system for relevant literature including: AGRICOLA (1984 to 1997); Commonwealth Agricultural Bureau Abstracts (1972 to 1997); and Zoological Record (1978 to 1997). In-office we searched cataloged, personal reprint collections and commercially available computer databases. In-office collections searched included: W. E. Howard (24,000+ citations); W. P. Gorenzel (9,500+ citations); Duck Data (9,500+ citations compiled by U.S. Fish & Wildlife Service); Wildlife (8,000+ citations from the Journal of Wildlife Management, Wildlife Monographs, and the Wildlife Society Bulletin, 1937 to present); and Ornithology (16,500+ citations from the Auk, Condor, Wilson Bulletin, Journal of Field Ornithology, Studies of Avian Biology, and Ornithological Monographs, 1955 to present). The Howard and Gorenzel collections were highly specialized with wildlife damage management-related literature. We also maintained an on-going search for literature in Current Contents.

California County Bird Trapping Programs

We used the questionnaire and California Department of Food and Agriculture (CDFA) annual 3-A reports from 1991 to 1995 to obtain information on county bird trapping programs.

RESULTS

Questionnaire

Response. We mailed 477 questionnaires. Thirteen questionnaires were subsequently removed from the analyses (seven returned for insufficient addresses and six identified as inappropriate recipients). Two hundred fifty questionnaires were returned: 164 returns from the original mailing and 86 returns from the follow-up letters. The overall return rate was 54%.

We received returns from all 50 states and 1 territory (Puerto Rico). California had the greatest number of returns (n=57), followed by Pennsylvania (n=15), Connecticut (n=13), New York (n=10), and Illinois, Massachusetts, Michigan, and Wisconsin (n=8 each). Returns from these eight states represented 51% of all returns.

By affiliation, most questionnaires were mailed to private industry (57%), which also had the lowest return rate for any group at 36% (Table 1). Federal and county organizations had outstanding return rates (>90%). Fifty-one of the 52 returns from county-affiliated respondents were from California Agriculture Commissioners, representing all but one of the counties in California.

Table 1. Number of bird trapping questionnaires mailed out, returned, and return rate according to type of organization (federal, state, county, or university) or private business affiliation (nuisance, wildlife control operator, pest control operator, grower).

Organization	Mailed Out	Returned	Return Rate %
Federal	38	36	94.7
State	57	37	64.9
County	57	52	91.2
Private	263	96	36.5
University	49	29	59.2
Total	464	250	53.9

Services provided. With regard to trapping, 133 respondents (53%) indicated they either trap, monitor, or provide information on bird trapping, while 117 respondents (47%) indicated they are not involved in any aspect of bird trapping. Most respondents with federal, university, or private affiliations were involved to some degree with bird trapping (Table 2). In California 29 (58%) of the 50 counties reporting provided some service related to trapping.

Regarding specific service(s) offered, 130 people responded and 62 or nearly half (48%) trapped (Table 2). Providing information was the service provided most frequently. By affiliation, over 90% of private respondents trapped, followed by 60% of federal respondents. Few county (3%), university (10%), or state organizations (33%) conducted trapping.

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Table 2. Questionnaire responses on whether the individual or organization conducts, monitors, or provides information concerning bird trapping.

Service Provided	Organization					
	Federal	State	County	Private	University	Total
Conduct trapping	2	0	0	21	0	23
Monitor trapping	0	0	0	1	0	1
Only provide information	12	5	19	3	17	56
Conduct and monitor	0	0	0	3	0	3
Conduct and provide information	9	2	0	8	1	20
Monitor and provide information	0	1	10	0	0	11
All three activities	7	1	1	6	1	16

In California, of the 29 counties that provided some form of bird trapping services, only Sonoma County conducted trapping, 10 counties (Fresno, Glenn, Kern, Los Angeles, Napa, Orange, San Benito, San Joaquin, San Luis Obispo, Tulare) monitored trapping and provided information, and 18 counties (Alameda, Calaveras, Colusa, Contra Costa, El Dorado, Kings, Madera, Mariposa, Merced, Monterey, Sacramento, San Francisco, Santa Cruz, Shasta, Solano, Sutter, Trinity, Yuba) provided only information. The remaining counties did not provide any bird trapping services or did not respond.

Pest birds and damage. Respondents listed 53 species and seven groups of species (e.g., herons, gulls, woodpeckers, raptors) that caused damage to crops, animal production facilities, or non-agricultural sites. However, nine individual species comprised 60% of the responses for birds causing damage (Table 3). The five individual species cited most often as causing damage to crops were European starling (n=52), Canada goose (n=31), American crow (n=29), house finch (n=23), and red-winged blackbird (n=19). At animal production facilities, the five top-ranked species causing damage were European starling (n=46), rock dove (n=21), double-crested cormorant (n=20), great blue heron (n=17), and house sparrow (n=14). At non-agricultural sites, the five top species causing damage were rock dove (n=71), European starling (n=27), house sparrow (n=23), Canada goose (n=14), and American crow (n=7). Overall, starlings (n=125), blackbirds (n=116), rock doves (n=104), and ducks and geese (n=71) were most frequently listed.

Respondents listed 51 specific crops and 18 types of livestock or animal production facilities subject to bird damage (Table 4). Sixteen non-crop sites or conditions warranting control actions were also cited. The majority of responses (60%) from private industry listed bird species and locations indicative of non-agricultural sites and damage (Table 5). The species and damage listed on returns from counties in California showed a heavy emphasis on agricultural bird damage (74%). Returns from federal agencies showed a more equitable mix of bird problems at both agriculture and non-agricultural sites.

Species trapped and traps employed. Respondents listed 25 bird species or groups of species that were trapped (Table 6). Some birds such as herons, egrets, raptors, golden eagles, wild turkeys, gulls, great horned owls, or common ravens, although listed, were not commonly trapped. Traps were employed on all the major damaging species (see Table 3) with the exceptions of double-crested cormorants (which were not reported trapped) and great blue herons (only one report as being trapped). The traps used most frequently on the major pest species included: drive traps for ducks and geese (n=15); walk-in traps for rock doves (n=53); modified Australian crow (MAC) traps for corvids, European starlings, blackbirds, and house finch (n=60); and funnel and walk-in traps for house sparrows (n=11). Overall, the MAC trap was used most frequently (n=68) and for the greatest number of species or groups of birds (n=13). A number of different traps (e.g., repeater trap, nest box trap, rat snap trap, mist net, elevator trap, glue trap) were used on occasion. In some instances, different traps named by respondents may have been the same trap, (e.g., funnel trap and walk-in trap used for house sparrow), but could not be combined into one category due to a lack of any further information on the questionnaire.

Trap management. Eighty-three percent of the 174 responses on trap management related to the major pest species: rock doves (n=51), European starlings (n=34), house sparrows (n=18), blackbirds (n=17), Canada geese (n=12), and house finch (n=12). Recommended trap placement for the agricultural damage situations was mostly around crop edges, along flyways, or near roosts (n=66). Trap placement for non-agricultural damage by rock doves, starlings, and house sparrows was mainly on rooftops, buildings, or other structures (n=42). Given the habits of rock doves, starlings, and house sparrows, the previous placement sites could also be feeding, roosting, or loafing areas, which were frequently

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Table 3. Number of responses identifying the top-ranked individual species or groups of species causing damage to agriculture, animal production facilities, or non-agricultural sites.

Order	Species	Agriculture	Animal Production	Non-Agricultural	Total
Pelecaniformes	Double-crested cormorant (*Phalacrocorax auritus*)	0	20	0	20
Ciconiiformes	Herons and egrets[a]	0	37	3	40
	Great blue heron (*Ardea herodias*)	0	17	1	18
Anseriformes	Ducks and geese[b]	54	1	16	71
	Canada goose (*Branta canadensis*)	31	0	14	45
Falconiformes	Raptors[c]	0	26	3	29
Columbiformes	Rock dove (*Columba livia*)	12	21	71	104
Passeriformes	Crovids[d]	41	13	10	64
	American crow (*Corvus brachyrhynchos*)	29	5	7	41
	European starling (*Sturnus vulgaris*)	52	46	27	125
	House sparrow (*Passer domesticus*)	10	14	23	47
	Blackbirds[e]	80	28	8	116
	Red-winged blackbird (*Agelaius phoeniceus*)	19	3	0	22
	House finch (*Carpodacus mexicanus*)	23	0	0	23

[a]Herons and egrets include: great blue heron, great egret (*Casmerodius albus*), cattle egret (*Bubulcus ibis*), and black-crowned night heron (*Nycticorax nycticorax*).
[b]Ducks and geese include: swans (*Cygnus* spp.), snow goose (*Chen caerulescens*), Canada goose, and mallard (*Anas platyrhynchos*).
[c]Raptors include: black vulture (*Coragyps atratus*), turkey vulture (*Cathartes aura*), osprey (*Pandion haliaetus*), bald eagle (*Haliaeetus leucocephalus*), and golden eagle (*Aquila chrysaetos*).
[d]Corvids include: blue jay (*Cyanocitta cristata*), scrub jay (*Aphelocoma coerulescens*), black-billed magpie (*Pica pica*), yellow-billed magpie (*P. nuttalli*), American crow, and common raven (*Corvus corax*).
[e]Blackbirds include: red-winged blackbird, great-tailed grackle (*Quiscalus mexicanus*), boat-tailed grackle (*Q. major*), common grackle (*Q. quiscula*), and brown-headed cowbird (*Molothrus ater*).

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Table 4. Crops, animals, sites, or conditions listed by questionnaire respondents as receiving damage from birds or warranting control actions.

General Location	Specific Damage Sites or Conditions
Agriculture - Animal Production	Aquaculture: baitfish, catfish, crayfish, shrimp, striped bass, tilapia, trout.
	Livestock: birds, calves, cattle, dairies, ducks, feedlots, horse barns, lambs, mink ranches, ornamental poultry, turkeys.
Agriculture - Plant Crops	Forage/grass crops: alfalfa, grasses, hayfields, pastures, turf/sod farms.
	Berry crops: blueberries, caneberries, grapes/vineyards, raspberries, strawberries.
	Grain/related crops: barley, corn, milo, oats, rice, rye, soybeans, stored grains, sugarbeets, sunflowers, wheat, wild rice.
	Tree crops: almonds, apples, apricot, cherries, grapefruit, nectarines, olives, peaches, pears, pecans, persimmons, pistachios, plums, prunes, walnuts.
	Vegetables/other fruit crops: beans, broccoli, brussel sprouts, legumes, lettuce, melons, peas, peppers, potatoes, squash, tomatoes, watermelons.
	Miscellaneous crops: cut flowers, nursery stock.
Non-crop Sites	Health hazard/nuisance: air safety, buildings, other structures, bird roosts, boats, docks, golf courses, landfills, landscaping, lawns, stored equipment.
	Recreational fisheries: salmon, steelhead.
	Wildlife: endangered species, nests-birds, nests-waterfowl.

Table 5. Frequency of bird damage (agricultural includes crops, livestock, and aquaculture facilities; non-agricultural includes nuisance wildlife or public health situations; or both types reported by respondents from different affiliations).

	Organization				
Type of Damage	Federal	State	County	Private	University
Agricultural	15	8	28	13	15
Non-agricultural	2	0	1	31	1
Both	16	7	9	8	5

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Table 6. Birds or groups of birds identified by respondents as being trapped, the damaged crop or situation for which they are trapped, the type of trap used, and in parentheses the number of respondents reporting that a particular trap was used for control.

Species[a]	Crop or Location of Damage	Traps Used for Control
Herons and egrets	Aquaculture - trout	Pole trap (1)
Ducks and geese	Health hazard, nuisance, turf/sod, wheat, legumes	Cannon or rocket net (4), drive trap (3)
Canada goose	Aquaculture, livestock facilities, health hazard, nuisance, turf/sod, alfalfa, landscaping/lawns, pastures, barley, corn, grains, soybeans, wheat, millet, beans	Drive trap (12), cannon or rocket net (2), drop net (1), net gun (1), walk-in (1)
Raptors	Poultry	Bal chatri (1), pole trap (1), spring trap (1)
Golden eagle	Lambs	Padded leg-hold trap (2)
Ring-necked pheasant (*Phasianus colchicus*)	Corn	Walk-in trap (1)
Wild turkey (*Meleagris gallopavo*)	Corn	Cannon net (1)
Gulls	Buildings, structures	Nest trap (1)
Rock dove	Dairies, feedlots, livestock facilities, turkeys, health hazard, nuisance, buildings, structures, stored equipment, grass seeds, corn, stored grains	Walk-in trap (53), box tube trap (1), cannon net (1), glue trap (1), net trap (1), Q net (1), repeater trap (1)
Great horned owl (*Bubo virginianus*)	Poultry	Noose carpet (1)
Woodpeckers	Buildings or structures, fruit trees	Rat snap trap (2), mist net (1)
Northern flicker (*Colaptes auratus*)	Buildings or structures	Nest box trap (1)
American crow	Calves, corn seedlings, walnuts, apples	MAC[b] trap (4)
Common raven	Calves	MAC trap (1)
Black-billed magpie	Health hazard, nuisance, fruit crops, apples, cherries, depredation to bird's nests	MAC trap (2), funnel trap (1)
American robin	Grapes	MAC trap (1)
European starling	Dairies, feedlots, livestock facilities, health hazard, nuisance, buildings or structures, roosts, stored equipment, fruit crops, blueberries, caneberries, grapes, raspberries, strawberries, grains, milo, tree fruit, apples, cherries, nectarines, peaches, pears, plums	MAC trap (27), mist net (2), funnel trap (1), Italian trap (1), nest box trap (1), rat snap trap (1), repeater trap (1), walk-in trap (1)
House sparrow	Feedlots, livestock facilities, horse barns, health hazard, nuisance, buildings or structures, food processing sites, stored equipment, rye, stored grains, wheat	Funnel trap (6), walk-in trap (5), MAC trap (4), elevator trap (3), mist net (2), clap bow trap (1), glue trap (1), lever trap (1), repeater trap (1)

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Table 6. (continued)

Species[a]	Crop or Location of Damage	Traps Used for Control
Crowned sparrows (*Zonotrichia* spp.)	Grapes, cherries, broccoli seedlings, lettuce	MAC trap (2)
Blackbirds	Livestock facilities, grasses, blueberries, grapes, raspberries, corn, grains, milo, rice, sunflowers, fruit, apples, cherries, pears, endangered species	MAC trap (12), modified goshawk trap (1), walk-in trap (1)
Red-winged blackbird	Roosts, grains, rice, sunflowers, fruit	MAC trap (2), light trap (1)
American goldfinch (*Carduelis tristis*)	Strawberries	MAC trap (1)
House finch	Grapes, strawberries, tree fruit, apples, apricots, cherries, nectarines, peaches, pears, vegetable transplants	MAC trap (12)

[a]Some respondents listed groups of birds rather than individual species, e.g., blackbirds could include boat-tailed grackles, Brewer's blackbirds, brown-headed cowbirds, red-winged blackbirds, or other species in the family Emberizidae. If specifically mentioned by a respondent, however, red-winged blackbirds were reported separately.
[b]Modified Australian crow trap.

recommended (n=28). Traps for ducks and geese were typically placed near water (n=13). Traps for birds of prey and scavengers were usually set near a carcass, or the pasture, yard, or pen holding the prey species (n=4).

Prebaiting was recommended by 76% of 144 respondents for rock doves, crows, starlings, house sparrows, blackbirds, and house finch. Prebaiting was used by seven (44%) of the 16 respondents for Canada geese. Corn, either whole, cracked, or in combination with other grains or seeds, was the most common bait for rock doves, starlings, and house sparrows (n≥60). Baits for starlings were the most diverse and even included human foods such as french fries, popcorn, and potato chips. In crop settings, birds were often baited with the fruit in question (e.g., cherries, grapes, apples, n=15), or if at an animal production facility, with the food ration provided to the domestic animals in question (n=8). Water was listed as a bait for starlings, house sparrows, and grackles (n=3).

Live decoys were recommended by most respondents (65%) for rock doves, and by all of the respondents for the songbirds (see Table 6), except for house sparrows (47%) and the crowned sparrows (33%). Except for rock doves, decoys were not used for the non-passerine birds.

Common trapping mistakes. The most common mistakes listed by respondents (Table 7) concerned prebaiting/baiting (n=53), trap placement (n=38), and trap servicing (n=31). Many of the mistakes listed could be interrelated. For example, not enough prebaiting (n=22) could relate to impatience (n=10) or inexperience (n=3) listed under the general category of human and personnel factors. The common mistake of poor trap placement (n=35) could relate to not enough bird observations regarding flight lanes, roosting, and feeding areas (n=11).

Degree of control. All but four respondents rated trapping as giving at least slight control or more (Table 8). Among the major pest birds, the majority of respondents rated control as moderate to excellent (average control rating ≥2.0) for ducks and geese (76%), rock doves (83%), and house sparrows (75%). Major bird pests rating slightly less than moderate control (1.6 to 1.9) included the corvids, starlings, blackbirds, and house finch. Despite control ratings between 1.6 to 1.9, the majority of respondents still rated trapping as moderate or excellent for corvids (75%), starlings (56%), and house finch (70%), suggesting that trapping was at least moderately effective on most occasions. For house finch all of the respondents were from Agriculture Commissioner offices in California.

Examination of control ratings for selected species by organization highlighted differences. Most private-industry respondents (75%) rated control by trapping as moderate to excellent for starlings (Table 9). Conversely, 80% of the county respondents, all from California and predominately with agricultural bird damage concerns (see Table 5), rated control as slight.

The distinct differences between the above groups relate to the different situations where starlings may cause damage and the area over which control must be achieved. Control by trapping of starlings on an individual building or a limited area of a roost (a situation typical for private industry) is site specific and achievable. Control of starlings for an entire cherry orchard or a vineyard (a situation often encountered in California) by trapping is less achievable, hence the lower ratings by county affiliates.

A similar analysis for rock doves showed moderate to excellent control ratings by the majority of respondents in all organizations (Table 10). Despite the different orientation of county respondents and private industry with regard to agricultural or non-agricultural damage, there are similarities in the problems they and other groups confront with rock doves. In the agricultural

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Table 7. Responses regarding common mistakes committed during trapping operations, listed in descending order based on number of responses. Numbers in parentheses represent number of respondents listing a particular mistake.

General Category	Specific Comments
Prebaiting or baiting (53)	Not enough prebaiting (22), no prebaiting (18), wrong prebait (12), bait not fresh (1)
Trap placement (38)	Poor placement (35), not moving trap often enough (3)
Servicing traps (31)	Not regular or frequent enough (23), improper handling of trapped birds (4), not keeping bait and water available (3), not keeping trap in good repair (1)
Human and personnel factors (17)	Impatience (10), inexperience (3), too much human disturbance (3), not handling animal rights protesters (1)
Traps (14)	Bad design (6), not enough traps (4), traps too small (4)
Pretrapping observations (13)	Not enough bird observations re: flight lanes, roosting, and feeding areas (11), misidentification of target species (2)
Decoy birds (12)	Not using decoy birds (9), not using enough decoy birds (2), poor care of decoy birds (1)
Timing (10)	Starting to trap too late (7), wrong time of year to trap (3)
Nontargets (3)	Catching nontargets (2), mishandling nontargets (1)
Other external factors (2)	Not controlling other food and water sources (2)

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Table 8. Number of respondents indicating the degree of control obtained by trapping. Numerical values used for control ratings: none=0, slight=1, moderate=2, and excellent=3.

	Degree of Control				Control Rating	
Species[a]	None	Slight	Moderate	Excellent	$\bar{x}$	SE
Ducks, geese, and swans	1	1	3	4	2.1	0.4
Canada goose	0	2	2	4	2.2	0.3
Raptors	0	1	0	0	1.0	-
Vultures	0	0	1	0	2.0	-
Golden eagle	0	1	1	0	1.5	0.5
Galliformes[b]	0	2	0	0	1.0	-
Gulls	0	1	0	0	1.0	-
Rock dove	1	9	25	23	2.2	0.1
Great horned owl	0	0	1	0	2.0	-
Woodpeckers	0	1	3	2	2.2	0.3
American crow	0	1	4	0	1.8	0.2
Black-billed magpie	0	1	2	0	1.7	0.3
European starling	0	16	13	7	1.8	0.1
House sparrow	0	5	9	6	2.0	0.2
Crowned sparrows	0	1	2	0	1.7	0.3
Blackbirds	1	8	4	3	1.6	0.2
Red-winged blackbird	1	1	1	0	1.0	0.6
American goldfinch	0	1	0	0	1.0	-
House finch	0	3	5	2	1.9	0.2

[a]Some respondents listed groups of birds rather than individual species, e.g., blackbirds could include boat-tailed grackles, Brewer's blackbirds, brown-headed cowbirds, red-winged blackbirds, or other species in the family Emberizidae. If specifically mentioned by a respondent, however, red-winged blackbirds were reported separately.
[b]Includes one response each for ring-necked pheasant and wild turkey.

Table 9. Number of respondents listed by organization regarding the degree of control obtained by trapping European starlings.

	Degree of Control				
Organization	None	Slight	Moderate	Excellent	Total
Federal	0	2	3	1	6
State	0	1	0	1	2
County	0	8	1	1	10
Private	0	3	5	4	12
University	0	2	4	0	6
Total	0	16	13	7	36

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Table 10. Number of respondents listed by organization regarding the degree of control obtained by trapping rock doves.

Organization	Degree of Control: None	Slight	Moderate	Excellent	Total
Federal	0	3	4	6	13
State	0	0	2	2	4
County	0	1	3	1	5
Private	1	2	14	12	29
University	0	3	2	2	7
Total	1	9	25	23	58

arena, rock doves do not typically damage field or tree crops, but instead cause problems at animal production facilities. The responses indicated trapping may be employed in a similar manner at such limited, site-specific locations as feedlots or non-agricultural sites such as office buildings, with the same level of success.

Importance of trapping. Despite the favorable control ratings noted above, out of 99 respondents, 57% still considered trapping as not important in overall bird control in any crop. However, the remaining 43% of respondents indicated trapping was an important component in overall bird control for 17 species or groups of birds. The major damaging species, European starlings (n=18), rock doves (n=16), and house finch (n=10), Canada geese, house sparrows, and blackbirds (n=7 each), were listed most frequently. Among the ten California Agriculture Commissioners responding to this question, 70% and 100% listed starlings and house finch, respectively, indicating the importance of trapping these species in the agriculture-related damage situations in which their offices function. For both species the Commissioners most frequently cited grapes as the crop for which trapping was important for overall control.

Future role of trapping. One hundred four respondents addressed this question, 44% thought the use of trapping would increase in the future, 38% thought it would stay the same, and 18% thought it would decrease (Table 11). The attitude of increasing use was particularly strong in private industry (83%). The attitude of decreasing use was strongest in the county (31%) and federal organizations (26%).

When asked for reasons to explain the future trend in bird trapping, respondents who predicted increasing use cited the loss of toxicants and repellents (n=13), good results from trapping (n=10), public acceptance of trapping over toxicants (n=5), and restrictions on or lack of other methods (n=3). Those suggesting decreasing use cited the ineffectiveness of trapping (n=8), the cost and labor-intensive nature of trapping (n=7), animal rights, humane, or legal problems (n=4), changes in the magnitude of bird problems (n=3), and the availability of other techniques such as netting (n=3).

New strategies or trap designs. Respondents recommended new trap designs or improvements to existing traps (Table 12). Most of these suggestions concerned rock doves, house sparrows, or trapping in or around buildings. Under trapping strategies many respondents recommended specific traps and tips on field operations. Suggestions from respondents reinforced standard trapping procedures concerning pre-trapping observations, prebaiting, proper bait selection, frequent trap servicing, using enough traps, proper trap location, and trapping before damage begins. Novel approaches included the use of decoy birds to attract raptors to discourage pest birds, taped calls to lure birds into traps, and the use of decoy birds to lure pest birds to the area for application of a different control method.

Table 11. Number of respondents listed by organization to the question, "In the future do you expect increased, decreased, or the same use of traps for bird control in agriculture?"

Use of Traps	Organization: Federal	State	County	Private	University	Total
Increasing	10	1	4	24	7	46
Staying the same	10	6	14	3	6	39
Decreasing	7	1	8	2	1	19

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Table 12. Responses to the question asking for suggestions for any new or improved trap designs or strategies that might increase the usefulness of bird trapping. Where listed, numbers in parentheses represent number of respondents giving a particular suggestion. For all other suggestions only one respondent made the suggestion.

Subject	Category	Specific Comments
Traps	New designs needed (8)	Design new traps; double compartment pigeon trap with mesh push-up door; electronic release drop net; escape-proof pigeon trap; heated trap for night roosting birds in cold-weather areas; large collapsible trap with netting; large lightweight trap with "invisible" wire sides and frame; modifications to prevent escapes from MAC[a] traps; "silent" cannon net trap; winterized trap designs.
	Trap improvements recommended by respondents (4)	Collapsible house sparrow decoy trap; improved MAC trap for blackbirds; improved pigeon trap; modified pigeon trap to decrease escapes.
Trapping strategies	Education (2)	Need training programs for biologists; need U.S. Fish and Wildlife Service certification course on use of mist nets.
	New approaches (5)	Modify structures used as roosts to facilitate trapping of roosting birds; test Potter traps for horned larks; use caged pigeons to attract hawks to discourage other pest birds; use decoy birds in trap to lure other birds in and then apply another control technique; use taped bird calls to lure birds to the trap.
	Recommendations for particular traps (10)	Existing traps and designs work (3); Kness Kage-All traps, rocket nets, Texas vulture trap, and Troyer V-top trap work well; use bob-type entrance rather than funnel entrance for pigeon traps; use large decoy traps in blueberries; use mist nets in flight lanes.
	Trap operation (9)	Bird identification, observations, prebaiting, etc., very important (2); check traps every day; keep traps in good repair to prevent escapes; get all vineyards in the area to participate using good practices; prebait; use large traps; do not set traps until birds are accustomed to them; alarm calls from trapped birds will make others wary; trap year-round for resident birds; trap before losses start; use bait that can compete with the crop; trap first near cover or roosts; move traps; use experienced personnel (2); use more traps/acre for starlings.

[a]MAC trap refers to modified Australian crow trap.

Literature Review

General trapping strategies. Balph and Balph (1981) discussed practical applications of behavioral principles to optimize trapping success for banders, a number of which apply to trapping for control. Birds are unlikely to enter unbaited traps, thus an attractant, generally a food, is used. The food should be highly palatable and be presented in a place or time when there are few alternative sources of food. Capture success is improved by trapping at times when birds' energetic needs are greatest, such as just before or after an overnight fast or when ambient temperatures are low. Social factors are important. For flocking species, the presence of decoy birds in a trap may serve as an attractant. Social intolerance may be used during the breeding season by using a live decoy male to capture territorial males. Social dominance, competition, or inexperience can result in trap bias with the catch composed predominantly of individuals of a particular age, sex, or weight class. For example, far more hatching year birds than adult grackles, starlings, and red-winged blackbirds were caught in decoy traps (Weatherhead and Greenwood 1981). This phenomenon is also common for house finch and starlings caught in MAC traps in California (P. Gadd, pers. comm.).

Trap design affects the mechanics of capture. A bird at a baited trap may not immediately perceive the correct route to the bait via the entrance on the other side of the trap. A bird on the side of a trap that cannot solve the problem typically moves back and forth along one side of

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the trap attempting to reach the bait. The bird repeatedly corrects what it perceives to be movement in the wrong direction and returns to the area nearest the bait. The problem is corrected by an entrance on each side of the trap, or a circular trap where the bird will never move farther away from the bait by walking around the trap (Balph and Balph 1981).

Traps and trapping techniques. We found dozens of references in the scientific literature describing a specific trap or technique to capture individual species of birds. The majority of these references were concerned with catching birds for scientific study (e.g., to measure, band, or radio-tag), and in most cases they were not pest birds. The traps and techniques described usually did not take into consideration factors desirable in a damage control setting (e.g., trap must be "self-running," practical, serviceable, and economical). As a result, these publications are not cited in this report.

Two publications warrant mention; both discuss potential problem species and their capture. Bub (1991) provides modern and historical accounts of trapping, primarily from Europe and Asia. Bub discusses most taxonomic groups of land and sea birds and describes the basics of trapping including bait selection, use of live lure birds, artificial decoys, and camouflage. He describes hundreds of traps including funnel, cage, and pit traps; stationary, bow, and clap nets; mist, hedge, tent, and pull nets; nooses; and cannon nets. Several traps described by Bub and discussed below may have application for North American bird species. Bloom (1987) describes traps for catching raptors, including bal-chatri, bow net, cannon and rocket nets, net gun, dho-ghaza (a mist or gill net suspended between two poles, and using an owl, small bird, or rodent as bait), noose carpet, padded leghold, phai (a ring of nooses), pit trap, Swedish goshawk trap, verbail (a perch or post type trap with a power snare), and walk-in traps. Bloom rates the effectiveness of these traps for 26 species of diurnal raptors and 18 species of owls from North America.

We found control-oriented publications (not cited in this report except for the examples below) with "how-to" trap information. Frequently these were short (<5 pages) publications discussing bird control in a particular crop or for an individual species. Typically these publications were produced by Cooperative Extension, or state or federal agencies (e.g., Fitzwater 1970; Clark and Crabb 1981). A control manual (Clark 1994) is noteworthy. It is specific to California and provides trap plans (e.g., modified Australian crow trap, cotton trailer trap, lily-pad trap, clover-leaf trap, funnel trap, bob-type walk-in trap, and circular magpie trap) and specific recommendations for trapping 12 species of pest birds.

Effectiveness of trapping in reducing damage. We did not find any scientific study designed specifically to measure the impact of trapping on the target species, damage reduction, and benefit-cost ratios. A number of references described operational trapping programs, e.g., bullfinch (*Pyrrhula pyrrhula*) control in fruit trees in England (Wright 1961), starling control in Washington (Bogatich 1966; Elliot 1964) and Colorado (Knittle and Guarino 1973), and house finch and starling control in California vineyards (Gadd 1996; Palmer 1970, 1972). However, as noted by Hone (1994), there have been surprisingly few rigorous evaluations of trapping's effectiveness and the factors influencing effectiveness. Hone's book, a comprehensive analysis of vertebrate pest control, contains no examples of studies evaluating bird trapping. Dolbeer (1986) noted that most evaluations of lethal bird control techniques put far more emphasis on the numbers of birds killed rather than the amount of damage eliminated in relation to the cost of control. For example, Elliott (1964) reported the use of 100 traps in the Yakima Valley, Washington, to kill 110,000 starlings from 1961 to 1963. He indicated the trapping practically eliminated damage to the cherry crop, but no benefit-cost data were provided. Similarly, Bogatich (1966) stated that although catches may be of only 500 birds or less, trapping contributed greatly to crop protection in Washington. No supporting data were offered.

Three studies provide partial benefit-cost data. Palmer (1972) indicated a combination of trapping and poisoning with strychnine was cost-effective in reducing bird damage in a fig plantation in California. During a three-year period 53,000 birds were removed and fig harvest increased 750%. However, the analysis did not include necessary data including labor costs and the value of figs, nor discuss possible differences in weather or cultivation between years, increasing production as trees age, or define how losses were determined. In addition, even through the percent of bird damage in relation to total harvest decreased from 11% to 1.4%, the total loss attributed to birds changed only from 1,900 lb in year 1 with no control to 1,800 lb in year 3 after control, suggesting that about the same number of birds were still present causing damage. Palmer (1976) used estimated consumption rates of pest birds at a feedlot to calculate a savings of about $250/mo from a control program employing trapping, hazing, and poisoning. The calculations apparently assume 100% control, but the degree of control attributable to any one control method was not delineated. Plesser et al. (1983) used mist nets in an Israeli vineyard to remove 2,700 house sparrows, eliminating all damage which equaled $4,500 the previous year. The overall saving of $4,100 accounted for the two workers required over a ten-day period but not the cost of the nets.

In addition to the general lack of thorough economic data, most studies lacked information on population levels pre- or post-trapping necessary for a thorough analysis of trapping. As an example, Knittle and Guarino (1973) reported on a nest-box trap program that removed 294 starlings and suggested the nest-box trap may be useful in small fruit orchards. However, without knowledge of the pre-trapping population nor any population modeling, an estimate of the impact of the removal of such a relatively small number of birds is not possible.

Knittle and Guarino (1973) and others should not be faulted for the lack of population data. In the past, modeling was not generally a consideration in control programs and population figures were not commonly available. Dolbeer (1998) illustrated the importance of models and demonstrated their use in determining how populations of different species will respond to management actions, such as trapping. As an example of the value of population data, an expensive trapping and shooting program for grey herons (*Ardea cinerea*) did not reduce heron abundance at fish farms in Europe (Van Vessem et al. 1985). Trapping and shooting probably would not have been undertaken if the benefits from the low number of herons taken were examined in relation to the costs and the total heron population in the region.

New trap designs or trapping strategies. According to Murton (1972), the traps in use today for catching birds embody nothing new in principle that was not already known to the ancients and that cannot be matched in ingenuity by hunting-gathering societies in existence today. Progress has been achieved with improved efficiency and materials rather than with new principles (e.g., coarse fibers have been replaced by modern, nylon mist nets). On the other hand, in these times when bird trapping is practiced by relatively few, a number of trap designs and techniques used in the past may have slipped from our common knowledge or may have application for species or situations different from those originally intended. We considered the traps or strategies listed below to have potential application to current bird problems.

1. Impact trap. This trap was originally designed to capture quelea (*Quelea quelea*) at night roosts (La Grange 1988). When disturbed at their night roost in tall herbaceous vegetation, quelea tend to fly up and forward short distances of 1 to 2 m each time. The impact trap is suspended in and slightly above the vegetation and consists of windows that only open inwards, with a hopper for collecting the birds below. As the birds are disturbed by drivers, they fly up, hit the trap windows, and fall into the trap. This trap may have application for blackbirds and starlings roosting in marsh vegetation such as cattails (*Typha* spp.) or bulrush (*Scirpus* spp.). Much would depend on the flight behavior of the birds when disturbed at the roost, which could be easily determined by field trials prior to construction of traps.

2. Modesto funnel trap. Feltes (1936) used this trap to catch 6,000 cedar waxwings (*Bombycilla cedrorum*) in Modesto, California. Feltes used raisins as bait in his custom-made trap to catch the waxwings on the flat roof of a raisin dehydrating and packing plant. Feltes discovered live decoy birds in each trap were highly successful in luring flocks of up to 3,000 birds. Palmer (1972) mentioned trapping 10,000 waxwings at a food processing plant in Kingsburg, California using MAC traps. Despite these two reports, it is not generally well-known that waxwings are trappable. Although a federal permit would be required to trap waxwings, the funnel trap or the MAC trap may have application in strawberries, cherry orchards, or other locations where large numbers of the birds have concentrated.

3. Noose-covered wickets. Crows and magpies have proven uncatchable in most situations in California using MAC traps with appropriately modified entrance slots or circular funnel traps as described in Clark (1994). Scharf (1985) describes a technique that could be applied to territorial crows and magpies nesting in or near orchards. The technique relies on the tendency of nesting, territorial birds to respond aggressively to an intruder in the vicinity of the nest. A caged, tethered decoy bird is placed in the center of an array of noose-covered wickets placed in a wagon-wheel configuration around the decoy bird. The wickets, similar to croquet wickets, are pushed in flush with the ground, leaving only the nooses exposed above ground. Catching the resident bird requires it to land and become ensnared in one of the nooses. Elimination of the captured bird(s) and destruction of a nest in an orchard, for example, could deter re-nesting and due to the absence of a nesting pair, reduce the attractiveness of the orchard for other crows. Noose-covered wickets might also be effective in almond varieties favored by feeding crows, especially around the edges of the orchard where damage is concentrated. A crow caught in a noose may give alarm and distress calls, frightening the rest of the feeding flock.

4. Perches coated with glue or glueboards. Fitzwater (1982) provides a brief review of bird lime for catching birds. Reidinger and Libay (1979) experimented in Philippine rice fields by spreading bird lime on branches extending 15 to 20 cm above the rice. Philippine weavers (*Lonchura* spp.) caught on the perches emitted distress calls, which tended to frighten other birds from the fields for another five days. As noted from the questionnaire, glue traps are used for rock doves and house sparrows. This approach might have application in rice or wild rice paddies, or breeding habitat along ditches around crops where breeding blackbirds customarily sing and display from high perches. Nontarget birds, such as the marsh wren (*Cistothorus palustris*) could be a problem. Reidinger and Libay suggested restricting the use of perches to the stages of crop growth when damage is most likely, and by designing perches that are preferred by the pest species, the impact on nontarget species could be reduced. Although we know of no specific restrictions on the use of glue on perches or glueboards for bird control, the legality of their use with regard to humane laws needs clarification by legal authorities.

5. Decoy-crop trapping. Norris and Whitehouse (1970) describe the use of a net trap to protect experimental cereal plots from house sparrows at a research station. Since it was impossible to attract the sparrows to traps once the cereal plots reached the milk stage, it was decided to try to trap them on the crop. Very early ripening cultivars were planted, followed by a succession of other cultivars ripening at intervals. The intention was to have the first of the decoy cereals at the milk stage before any of the valuable experimental plots. These plantings were covered with a net on all sides supported by metal poles. One end had a cylindrical cavity into which the birds could be driven for removal. A gap 0.3 to 0.6 m wide was left in the top netting so the birds could drop down into the trap. This technique uses the principle of the lure crop designed to entice birds away from some other planting, but with the added twist of enclosing the lure crop within a trap to actually remove the birds, rather than just drawing them away from some desired area. This approach could be used as above to protect small plots of valuable research plantings. It might also have application for crops where early ripening varieties are available, and where it is economical to set aside a portion of the crop for the birds. Grapes, strawberries, rice, nut and fruit trees, and cereals may be candidate crops.

6. Trammel nets and mist nets. Trammel nets and mist nets are primarily used by banders to capture

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songbirds. Trammel nets tend to be about 1.8 m high and of various lengths. Trammel nets consist of three layers, two coarse, large-meshed nets hung on the outside, and a fine-meshed net hung on the inside. The meshes of the coarse nets are large enough and lined up so that songbirds "think" they can pass through. The fine net is loose enough so that any bird flying into it will push on through the coarse mesh, pulling the fine net through, to be captured in a pocket. Essentially no bird can escape from a trammel net (Bub 1991:126). A variation on the standard trammel net is the push net, which are low nets held in place by short poles pushed into the ground (Bub 1991:130).

Mist nets were developed by Japanese hunters over 300 years ago. Modern mist nets are made of very fine, almost invisible nylon. Standard size is about 2.1 x 9.1 m. Mist nets differ from trammel nets in that birds are not captured in individual pockets. A mist nest consists of a series of horizontal shelves. Each shelf is essentially a long hammock into which the birds will fall. Birds fly into the net, fall or flutter down, and become entangled in the netting of the shelf so that they cannot escape (Bub 1991:137). Keyes and Grue (1982) give an excellent review of the use of mist nets and related mist net literature with 240 references.

Mist or trammel nets have been used in agricultural settings for bird control. Bruggers and Ruelle (1982) reported the netting of over 324,000 birds, mostly village weavers (*Ploceus cucullatus*) over a five-year period in Gambia. Plesser et al. (1983) used mist nets to remove house sparrows from vineyards in Israel. McClure (1956) described the use of mist nets in rice paddies in Japan.

Mist nets and trammel nets could be used on pest birds in North America. Nets could be used in a similar manner as described by Bub (1991:132) at night roosts of starlings and blackbirds in marshes. Bub (1991:133-134) also described the use of nets and drivers on the Russian steppes to catch Eurasian skylarks (*Alauda arvensis*). Skylarks are closely related to horned larks, suggesting this technique may have application in the fields of seedling carrots, lettuce, sugar beets, celery, and other crops in California. Growers in California have consistently indicated the lack of any effective control for horned larks (Verte. Pest Control Res. Adv. Comm. 1996).

Nets have several limitations. Nets must be tended while in operation to release any nontargets captured. Mist nets are fragile and easily damaged while removing birds. Although we found no federal or state legal restrictions on their possession, mist nets are not available to the general public. Suppliers require a federal bird banding permit number before purchase. A banding permit must be obtained from the U.S. Geological Survey, Biological Resources Division, Patuxent Wildlife Research Center, Bird Banding Laboratory in Laurel, Maryland. Permits are normally only granted for research or collecting purposes.

<u>Legal aspects of bird trapping</u>. Clark (1994) listed the federal and state regulations and permit requirements that apply to trapping birds in California. Neither state nor federal permits are required to trap rock doves, starlings, and house sparrows. Crows, magpies, blackbirds, and cowbirds may be trapped without a permit if they are committing or about to commit damage. House finch, horned larks, and crowned sparrows may be trapped under the general supervision of the Agriculture Commissioner. An example of the conditions and paperwork required by the Agriculture Commissioner are given by Gadd (1996). All other birds are protected, requiring a federal depredation permit for trapping.

California Penal Code Section 597 applies to the humane treatment of birds in traps. Failure to provide an animal with "proper food, drink, or shelter or protection from the weather" is a punishable offense. This section applies to birds held in traps, such as a MAC trap, for prolonged periods. Andrews et al. (1993) provide two acceptable methods of euthanasia for captured birds, carbon dioxide and cervical dislocation. The injection of carbon monoxide into a holding cage covered by a plastic sheet as suggested in Clark (1994:705-1) is not an acceptable method unless commercially compressed carbon monoxide is used and a number of precautions are followed. Dead birds should be burned or buried.

<u>Historical aspects of bird trapping in California</u>. Piper and Neff (1935) was the foundation for bird control in California for decades. They described trapping methods only for scrub jays, house sparrows, magpies, and crows. Trapping is not discussed for house finch, and starlings are not even mentioned in the publication. These omissions are due to the absence of European starlings in California until 1942, when the first specimen was taken in Siskiyou County. Starling populations thereafter increased rapidly and they became distributed throughout most of California by the late 1950s (Palmer 1972). Severe starling damage to California's agriculture in 1961 prompted state and federal officials to hold conferences and undertake research on starling control. The joint research efforts produced a large number of reports published in the series, "Progress reports on starling control" from 1963 to 1967. Some of the studies reported on tests of traps (e.g., Johnson et al. 1964; Marsh 1964; Wetherbee and Marsh 1964). These reports and others of research in the Northwest (e.g., Elliott 1964) brought the use of the MAC trap and the larger, converted cotton trailers into the mainstream of starling control. During this time it was discovered the MAC trap was also effective on house finches (Palmer 1972). Subsequently, in the late 1960s and 1970s a series of publications described starling or house finch control in various counties or regions (Clark 1967; Wright 1967; Palmer 1970; McCracken 1972; Clark 1973) and in various crops or cattle feedlots (Siebe 1967a, b; Palmer 1976). Gadd (1996) described the procedures of the sole remaining county-operated bird trapping program in California.

<u>California Bird Trapping Programs</u>

<u>Current levels of bird trapping in California counties</u>. The CDFA annual Report 3-A compiles data on the species and number of birds taken in the counties (Table 13). As house finch are controlled under the supervision of the Agriculture Commissioner, their inclusion in the report indicates that a particular county actually monitored house finch trapping programs. Report 3-A from 1991 to 1995 indicated only five counties in which house finch were taken (Fresno, Kern,

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Table 13. The average, standard error (SE), minimum, and maximum number of house finch and European starlings trapped per year from 1991 to 1995 in five California counties as reported in Report 3-A, compiled by the California Department of Food and Agriculture.

	House Finch				European Starling			
County	Mean	SE	Minimum	Maximum	Mean	SE	Minimum	Maximum
Fresno[a]	6,508	1,300	2,843	10,374	-	-	-	-
Kern	50,585	4,225	40,754	65,718	-	-	-	-
San Luis Obispo	1,934	395	990	3,287	-	-	-	-
Sonoma	4,088	754	2,279	6,565	1,104	102	958	1,502
Tulare[a]	35,092	3,239	23,747	42,288	-	-	-	-

[a]Birds taken by shooting and trapping.

San Luis Obispo, Sonoma, Tulare). Trapping and shooting were both employed in Fresno and Tulare counties; we assumed the vast majority of house finch were taken in traps. Fresno County consistently reported taking horned larks. We are not aware of any trapping for larks, thus we assumed the horned lark numbers were from shooting. Six additional counties (Glenn, Los Angeles, Napa, Orange, San Benito, San Joaquin) indicated on the questionnaire that they monitored trapping and yet did not report a take of species that would be controlled under their supervision (crowned sparrows, horned larks, house finch). Sonoma County, with a county-operated trapping program, was the only county to report a take of starlings. Starling trapping is undoubtedly more widespread than indicated by Report 3-A. The basis for this assumption is that most of the house finch are taken by private operators as all counties, except one, did not actively trap. As house finch and starlings damage many of the same crops (e.g., grapes, soft fruits), we assume traps for starlings were also employed by private operators. Starling control by trapping is not under the supervision of the Agriculture Commissioner, thus the number of starlings taken would not be reported or included in Report 3-A.

DISCUSSION

Based on results from a questionnaire and a review of the literature, we conclude that:

1. Trapping to control bird damage in both agriculture and non-crop situations is commonly used or recommended across the country by a broad segment of wildlife damage control practitioners. The mailing list of 464 names sampled a mix of individuals from county, state, federal, and business organizations from different regions of the country. The return rate (54%) was very good. Over half of all respondents (54%) were involved with trapping at some level, and within that group nearly half (49%) actually trapped.

2. Trapping is important in the control of selected species. Respondents listed 25 species that were trapped to some degree. Traps were used for all of the major pest species (except cormorants and herons). Respondents indicated trapping was an important component of overall control for starlings, rock doves, house finch, blackbirds, house sparrows, ducks, and Canada geese. Of the ten California Agriculture Commissioners that listed any species for which trapping was an important control tool, 70% and 100% listed starlings and house finch, respectively.

3. Trapping is important for bird control in selected crops and non-crop situations. Respondents indicated trapping is important for the major pest species listed in 2 above in particular crops or situations. Rock doves, house sparrows, ducks, and Canada geese were likely to be trapped at buildings, livestock facilities, stored grains, or health hazard/nuisance situations. Trapping of starlings and house finch was particularly important in grapes and other fruits.

4. Trapping will continue to be used at the same or increased levels in the future. One hundred four respondents addressed the future role of trapping; 82% expected the level of trapping to remain the same or increase. This finding is due to the importance respondents placed on trapping for selected species at various sites, because it is an available method that to some degree replaces the loss of toxicants and repellents, and because it is socially acceptable.

5. There is a substantial body of literature on trapping techniques, but trapping for bird control has not been rigorously evaluated from a cost-benefit standpoint. We found hundreds of papers on bird trapping, with most papers covering specific techniques to catch birds for scientific study. A small number of papers described trapping programs to reduce damage. Results were usually presented as number of birds taken. We did not find any study specifically designed to analyze bird trapping on an economic basis. In most cases the economic data were incomplete, based on subjective evaluations, or were a secondary finding of the study or project.

6. Bird trapping can be improved with new trap designs and strategies. Although some felt that trapping has reached its limits, many felt that there is still room for improved traps and innovative application of both old and new technology. Questionnaire respondents offered many suggestions for improving existing trap designs and

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efficacy. Our review of the literature revealed several new traps or strategies with potential application for bird control.

7. Additional research may be beneficial. As mentioned above, bird trapping has not been rigorously evaluated from a cost-benefit standpoint. As an example, most respondents in California indicated trapping is important for house finch control, especially in grapes. Yet, there has been no demonstration of the extent of the benefit derived from finch trapping, and considerable numbers are trapped, presumably at considerable expense.

Basic feasibility studies could examine the potential of new traps. Study of the behavior, flight patterns, and habitat use of horned larks in cultivated fields, and of blackbirds in wild rice or at marsh roosts could determine if new traps or strategies may be effective for these species. The potential of noose-covered wickets for crow and magpie control is another topic. Evidence from control efforts in almond orchards in Washington (Gardner 1926) indicated that only one or a small number of crows in distress deterred entire flocks from feeding. The reaction of feeding crows to a crow caught in a noose on an orchard floor deserves study.

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