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Crop diversification leads to diverse bird problems in Hawaiian agriculture

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Crop diversification leads to diverse bird problems in Hawaiian agriculture

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Abstract:
Over the last 20 years, Hawaii's agriculture has shifted from a focus on sugar cane (*Saccharum officinarum*) and pineapples (*Ananas comosus*) produced on large farms to a diverse array of products produced on a multitude of smaller farms. This dramatic shift in production, in addition to the introduction of many new avian species, has resulted in a concomitant change in the problems faced by agriculture. We surveyed farmers to determine the extent of bird damage to crops, the species responsible, the crops most vulnerable, and control methods employed. Bird problems varied by island, but cardinals (*Cardinalis cardinalis, Paroaria coronata,* and *P. capitata*) and pheasants (*Phasianus colchicus* and *Lophura leucomelanos*) were significant problems on all islands. Seed corn (*Zea mays*), fruit, vegetables, rice (*Oryza sativa*), and orchids (*Orchidaceae*) all sustained notable damage to their crops by birds, and growers expressed much interest in gaining information on control measures. Most farmers incurred little damage, while a few reported losing 80 to 100% of their crops at certain times of the year. We recommend a multidimensional approach to control invasive bird species, including habitat alterations, scare tactics, cessation of game bird releases, prevention of the spread of known pests among islands, and the development of chemical repellents for use when other methods are not sufficient.

Key words: agriculture**,** birds, damage, Hawaii, human–wildlife conflicts, invasive species, perceptions

PATTERNS OF CHANGE in agriculture in the state of Hawaii over the last 20 years contrast remarkably with those of the continental United States. Whereas farms on the continent have become larger and more monotypic, Hawaii's agriculture has blossomed from a few primary plantation crops produced on large farms to a great variety of agricultural products produced on many smaller farms (Hawaii Agriculture Statistics Service [HASS] 1984, 2002). Concomitantly, populations of nonnative avian species have increased, possibly in response to a shift in agriculture, resulting in severe avian depredation problems.

Hawaii is host to more species of nonnative breeding birds than any other state in the nation. Even more notable is the fact that nonnative species outnumber extant native species two-to-one. At least 56 species of nonnative land birds and water birds have resident breeding populations on the main Hawaiian Islands, compared to only 27 indigenous resident breeding species (compiled from Pratt et al. 1987). While most extant native species are restricted to higher elevation forest reserves (Benning et al. 2002), introduced species are dominant throughout the lowlands, which were largely cleared by the Polynesians (400 AD) and subsequent European settlers (late 1700s), leading to recent conflicts between nonnative birds and agriculture.

Japanese white-eye.
(Photo courtesy K. W. Bridges)

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Avian species were, and continue to be, introduced for a variety of reasons, including release of caged birds, sport hunting, and aesthetics (Mooney and Hobbs 2000). Introduced avian species act as reservoirs and vectors for avian disease, dispersal agents for noxious weeds, competitors with native species for limited resources, and severe agricultural pests (Cox 1999). Despite potential agricultural damage by many species of game birds, including ring-necked pheasants (*Phasianus colchicus*), chukar (*Alectoris chukar*), black francolin (*Francolinus francolinus*), gray francolin (*F. pondicerianus*), Erckel's francolin (*F. erckelii*), and California quail (*Callipepla californica*), state agencies, individuals, and private hunting organizations continue to release new stock and new species throughout the island chain. Such releases please bird hunters, but often occur at a great cost to farmers, gardeners, native species, and those involved in efforts to conserve endangered species.

Diversification of Hawaiian agriculture and increases in nonnative bird populations have led to conflicts between farmers and birds. Many new and diversified crops are highly desirable food items to nonnative birds. However, little is known about wildlife depredation in Hawaiian agriculture, and data has not been previously collected in national surveys (Wywialowski 1994). Sugar cane (*Saccharum officinarum*) and pineapple (*Ananas comosus*), neither of which experience much bird depredation, were once the dominant crops on the landscape. Both crops have experienced marked declines in acreage (HASS 1984, 2002; Figure 1). In 1978, 328 sugar cane farms covered 40,090 hectares whereas today just 2 sugar cane farms cover 9,753 ha. Similarly, pineapple acreage has been reduced by about 60%, from 10,244 hectares to 4,132 ha (Figure 1). Farmers continue to convert former sugar cane and pineapple land to a variety of new crops, including longan (*Dimocarpus longan*), rambutan (*Nephelium lappaceum*), lychee (*Litchi chinensis*), coffee (*Coffea* spp.), seed crops (primarily corn [*Zea mays*] and soybeans [*Glycine max*]), ornamental plants, flowers, vegetables, citrus, and tropical hardwoods. The number of farms in the state has increased from 2,968 in 1979 to 3,482 in 2002 (HASS 1984, 2002). While the average pineapple or sugar cane farm cultivated 800–1200 hectares, fruit, vegetable, macadamia (*Macadamia tetraphylla*) nut, and coffee farms are often much smaller (1–12 hectares), allowing for more diversification on the landscape. Fallow fields (resulting from the decline of sugar cane and pineapple) and interspersed weedy vegetation provide abundant cover and breeding habitat, as well as alternative food supplies, for a variety of species.

This study focused on identifying avian species that cause the most damage to Hawaiian agriculture. Additionally, we solicited information on which crops incur the highest rates of avian depredation and which methods are reported to be effective in reducing damage by birds. The information gathered here will assist farmers in anticipating and preventing the establishment of pest species. Additionally, we identified avian species and specific crops to focus on for future research into repellents and control measures.

Methods

We sent out surveys to 998 members of the Hawaii Farm Bureau in early May 2004. The surveys consisted of 8 questions and space for comments (Appendix 1). Included with the surveys was a list of most of Hawaii's lowland avian fauna and identifying characteristics. This list helped farmers identify the avian species in their fields, orchards, greenhouses, and aquaculture ponds. Also included with the surveys were stamped return envelopes.

Crops were categorized as fruits, vegetables, seed corn, coffee, macadamia nuts, flowers, pineapples, orchids (*Orchidaceae*), soybeans, herbs, rice (*Oryza sativa*), ti (*Cordyline terminalis*), taro (*Colocasia esculenta*), potatoes (*Solanum tuberosum*), ginger (*Zingiber officinale*), honey, aquaculture, landscaping and wood products, and livestock. Corn was a separate category from vegetables because most corn grown in Hawaii is grown for seed. Seed corn is often dominant on the landscape, has extremely high monetary value, and experiences intense bird pressure. Complaints about specific bird species were assessed individually for each island and also for the state as a whole.

Results

Most responses came from farmers on the Big Island of Hawaii. We also received responses from farmers on Kauai, Oahu, Maui, Molokai,

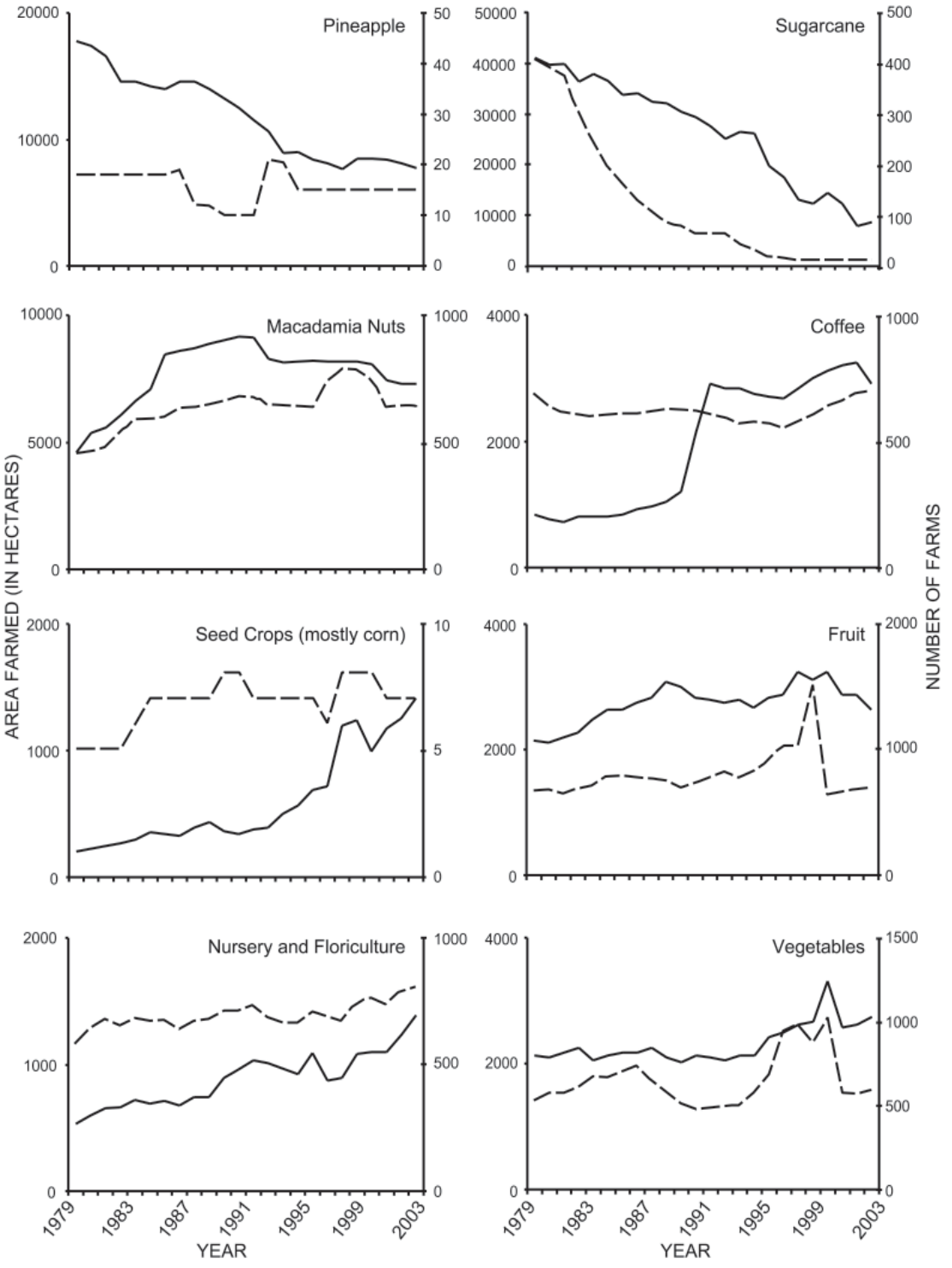

Figure 1. Diversification in Hawaiian agriculture from 1979 through 2002. Total area farmed in hectares (solid line) is shown on the left axis while the number of farms (broken line) is shown on the right axis. Data reported by National Agricultural Statistics Service.

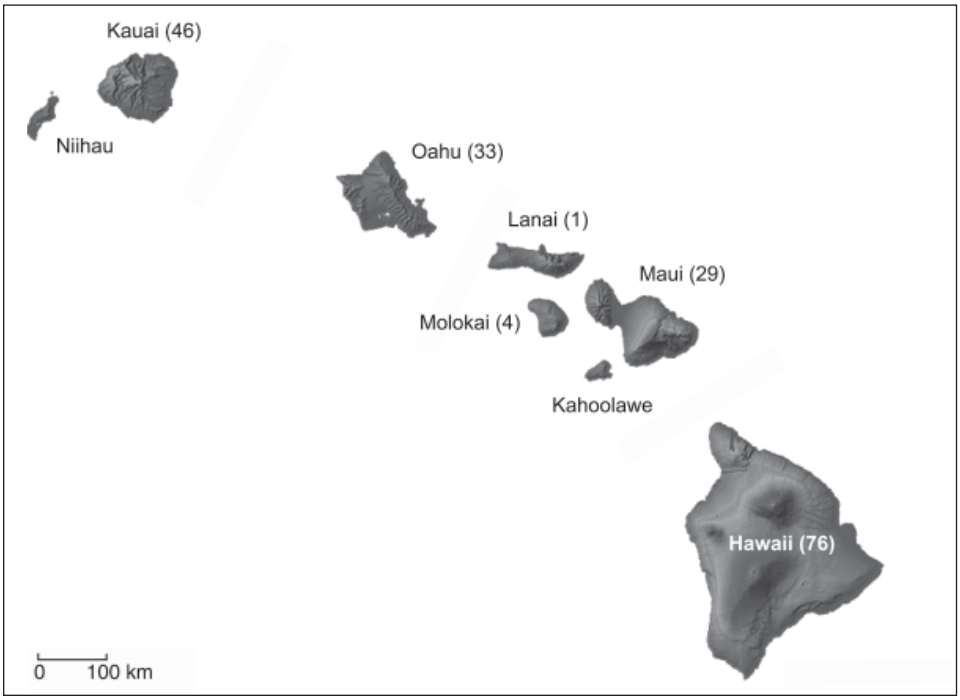

Figure 2. Map of the state of Hawaii and the number of respondents from each island (in parentheses).

and Lanai (Figure 2). Eight respondents did not indicate on which island they were located.

Respondents reported growing fruit (n = 52), coffee (n = 32), vegetables (n = 31), flowers (n = 29), macadamia nuts (n = 26), landscaping or wood products (n = 24), livestock (n = 21), corn (n = 18), orchids (n = 10), soybeans (n = 7), pineapple (n = 7), taro (n = 6), aquaculture (n = 4), ti (n = 3), ginger (n = 2), herbs (n = 2), potatoes (n = 2), rice (n = 2), and honey (n = 1). Based on our crop classifications, 111 respondents were classified as growing a single type of crop even if they grew multiple varieties within the same classification (e.g., a farmer growing lychee and lemons [*Citrus limon*] would be classified as growing just fruit). Forty-nine respondents reported growing 2 types of crops (e.g., coffee and macadamia nuts), twenty-two reported growing 3 crops, and two reported growing more than three. The remaining 13 respondents did not report their crops.

Avian species causing agricultural damage

Respondents complained about 38 species of birds in their crops; 6 species were native, and thirty-two were introduced. We received the most complaints about cardinals (*Cardinalis cardinalis, Paroaria coronata,* and *P. capitata*), pheasants (*P. colchicus* and *Lophura leucomelanos*), doves (*Streptopelia chinensis* and *Geopelia striata*), chickens (mostly *Gallus gallus*), and sparrows (mostly *Passer domesticus*). Problem birds varied slightly by island (Table 1), but cardinals and pheasants were always one of the top five. Bulbuls, established only on Oahu, received many complaints on that island (Table 1). Similarly, rose-ringed parakeets are found in large numbers only on Kauai, where they have become a significant pest species (Table 1).

Crops that experience the most damage by birds

Respondents were hesitant to report monetary values for damage and control measures, and when they did, the numbers were unreliable. Respondents did express their level of interest in new bird control measures, however, with seed corn and vegetable growers having the highest interest in learning about new control measures (Figure 3).

Among crops with the most severe problems, the species composition of bird pests was similar (Table 2), except for greenhouse-grown orchids. Orchids experienced higher depredation by cardinals (*Cardinal cartinalis*) and small-bodied birds such as house finches (*Carpodacus*

Table 1. Ten bird species receiving the most complaints by Farm Bureau members on each main Hawaiian island except Lanai (no data) and all islands combined. The number of respondents that complained about each species is shown in parentheses. Bird identification was not always reliable; sparrows, finches, and mannikins may have been confused.

Hawaii (*n* = 76)	**Kauai (*n* = 46)**	**Maui (*n* = 29)**	**Molokai (*n* = 4)**	**Oahu (*n* = 33)**	**All islands (*n* = 197)**
cardinal[1] (29)	chicken (41)	pheasant (18)	cardinal (3)	cardinal (14)	cardinal (53)
Japanese white-eye (19)[2]	cardinal (37)	francolin (17)	finch (3)	dove (12)	pheasant (45)
pheasant[3] (16)	pheasant (36)	sparrow (10)	francolin (3)	sparrow (11)	dove (35)
wild turkey[4] (16)	dove (22)	cardinal (9)	pheasant (2)	bulbul[16] (11)	feral chicken (34)
common myna[5] (13)	parrot[11] (16)	dove (8)	sparrow (2)	pheasant (8)	sparrow (31)
finch[6] (13)	common myna (15)	chukar (7)	java sparrow (2)	java sparrow (8)	common myna (30)
chicken[7] (11)	mannikin (13)	common myna (6)	dove (1)	finch (7)	Japanese white-eye (27)
sparrow[8] (10)	francolin[12] (11)	wild turkey (6)	chicken (1)	francolin (7)	finch (27)
dove[9] (8)	rock pigeon[13] (9)	java sparrow[15] (5)	mannikin (1)	mannikin (6)	francolin (23)
mannikin[10] (5)	nene[14] (9)	Japanese white-eye (4)	wild turkey (1)	common myna (3)	mannikin (19)

[1] northern, red-headed, and yellow-billed
[2] *Zosterope japonicus*
[3] ring-necked and kalij
[4] *Meleagris gallopavo*
[5] *Acridotheres tristis*
[6] house finch (*Carpodacus mexicanus)* and other small finch-like birds
[7] red junglefowl and other feral chickens
[8] house sparrows and other small sparrow-like birds
[9] spotted and zebra
[10] chestnut (*Lonchura malacca*), chestnut-breasted (*L. castaneothorax*), and nutmeg (*L. punctulata*)
[11] rose-ringed parakeet (*Psittacula krameri*)
[12] gray, black, and Erckel's
[13] *Columba livia*
[14] Hawaiian goose (*Branta sandwicensis*)
[15] *Padda oryzivora*
[16] red-vented (*Pycnonotus cafer*) and red-whiskered (*P. jocosus*)

Table 2. Top five bird species reported as problems in agriculture by members of the Hawaii Farm Bureau. In parentheses are percentages of respondents growing particular crops who complained about each species. Crops without significant bird problems or with fewer than 10 responses are not shown.

Fruit (*n* = 52)	**Vegetables (*n* = 31)**	**Flowers (*n* = 29)**	**Orchids (*n* = 10)**	**Corn (*n* = 18)**
cardinal (42%)	pheasant (68%)	pheasant (28%)	cardinal (30%)	pheasant (78%)
chicken (31%)	cardinal (45%)	cardinal (24%)	finch (30%)	cardinal (67%)
pheasant (29%)	dove (39%)	dove (24%)	Japanese white-eye (30%)	dove (67%)
common myna (29%)	francolin (32%)	sparrow (21%)	sparrow (20%)	francolin (61%)
Japanese white-eye (21%)	feral chicken (29%)	francolin (17%)	mannikin/bulbul (10% each)	sparrow/mannikin (39% each)

mexicanus), Japanese white-eyes, house sparrows, and mannikins *(Lonchura* spp.). In contrast, field crops (vegetables, fruit, corn, and flowers) experienced depredation primarily by gallinaceous birds, cardinals, and doves (Table 2).

Effective control measures

About half of the respondents (53%) reported that they took no action in preventing bird damage. Among the other half, some of the most common measures included netting (39%), reflective tape or foil (33%), and shooting (34%) to kill or scare the birds. Netting was one of the few control measures that was reported to be effective, but most respondents also complained that it was prohibitively labor-intensive. All 3 large seed companies that grew primarily corn hired full-time bird watchers to scare birds from the fields and used such techniques as shooting off guns and propane cannons, loudspeakers, and netting, among other techniques. They noted spending hundreds of thousands of dollars each year controlling birds.

Discussion

Responses from farm bureau members

Of the 998 surveys sent out, 197 completed surveys were returned, resulting in a 20% response rate. The response rate to our survey was expected from a mass-mailing where not all members were necessarily producers. Some nonrespondents may experience little bird depredation or they may not be producers. The proportion of respondents reporting each type of crop was not an accurate reflection of Hawaiian agriculture. Small owner-operated farms were well-represented among the respondents, but large, industrial farms growing pineapples, coffee, and sugar cane were less likely to reply. Ranchers and other farmers with few bird problems also replied in small numbers. Because respondents were likely biased towards smaller farms with more bird problems than the average farmer, it was difficult to accurately assess monetary losses due to bird depredation and the overall cost of bird control. Therefore, results on monetary values are not presented.

The results from this survey can be used to guide future avian depredation research in Hawaii. We identified which crops experience the most damage from birds, which crops may be at risk in the future (as they become more dominant on the landscape and bird populations increase), and which bird species inflict the most damage to Hawaiian agriculture.

Avian species causing agricultural damage

Overall, cardinals received the most complaints (12%). Three species of cardinals are found throughout the islands, but all three appear to cause damage in a similar manner. Cardinals often clipped small fruits in half without eating them, damaged vines and flowers, or pulled small seedlings from the soil. Cardinals were pests in both greenhouses and in open fields. Reports of cardinals as agricultural pests elsewhere are scarce. Tropical climate, lack of predators, and an abundance of attractive crops may have caused cardinal densities in Hawaii to far exceed those on the mainland. In addition, many Hawaiian locales host 2 or 3 separate species compared to the mainland where just 1 species occurs.

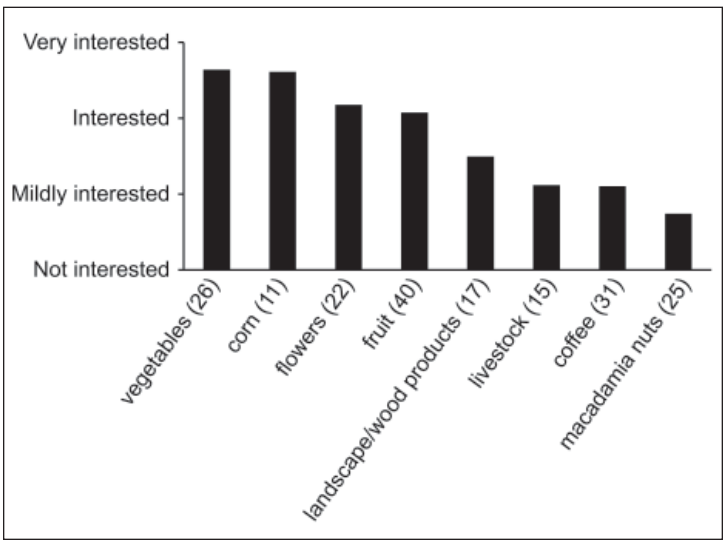

Figure 3. The average level of interest among each group of farmers in learning about new control measures for birds (sample size in parentheses).

Gallinaceous birds (combin-

Gray francolin. *(Photo courtesy USDA Natural Resources Conservation Service.)*

ed) accounted for 31% of all complaints. Gallinaceous birds are often pests in seed crops, which are some of the crops of highest monetary value. Due to the year-round growing season, many large seed producers (including Monsanto, Syngenta, and Pioneer) choose to test new hybrids or genetically modified strains in Hawaii. Gallinaceous birds often depredate these crops, thereby causing costly disruptions of the test process. Close to a million dollars (P. Koehler, Monsanto, personal communication and K. McMahon, Syngenta, personal communication) is spent each year to scare gallinaceous birds away from seed crops; at the same time, sport hunting organizations and state agencies continue to introduce new individuals and populations of game birds (Hawaii Division of Forestry and Wildlife 2001). Many farmers complained of the release of game birds adjacent to their fields and intense depredation at certain times of the year.

Crop damage was patchily distributed both spatially and temporally. Peer et al. (2003) reported that blackbird damage in the midwestern United States was often localized, thereby debilitating individual farmers while leaving others untouched. Similarly, many farmers in Hawaii reported losing 80 to 100% of their crop at certain times of the year or in specific areas. Newly planted fields of corn and other vegetables were more prone to depredation than fields that were older than 3 weeks. Flocks of Eurasian skylarks (*Alauda arvensis*), wild turkeys, francolin, or other birds often decimate an area while leaving adjacent fields intact, thereby inordinately impacting individual farmers. An intermittent supply or unexpected shortage of a crop can cause farmers to lose long-term clients and experience losses greater than just those incurred by lost production (R. Hirako, Hirako Farms, personal communication). Many farmers reported higher depredation during periods of drought or when game birds have young (which can occur throughout the year in a tropical climate).

Preventing the spread of invasive species among islands and into agricultural regions should be a high priority for corn growers and wildlife managers alike. Parrots, parakeets, and bulbuls are agricultural pests on the islands they inhabit, but they have not yet spread throughout the island chain. Due to their potential to cause widespread agricultural damage, efforts to prevent their spread should be given priority. Bulbuls damage a variety of crops and often infiltrate greenhouses. Their spread from Oahu to other islands is a major threat. Seed corn is grown on Maui, Kauai, and Molokai. On Kauai, rose-ringed parakeets are severe pests in seed corn and their control can be very expensive. Mitred conures (*Aratinga mitrata*) are potential agricultural pests (Bucher 1992) and are spreading on the west side of Maui. The spread of conures to the east side where seed corn is grown could prove disastrous for the industry.

Effective control measures

Netting was often listed as highly effective in keeping birds out of crops. However, it was also noted as being prohibitively expensive and time-consuming. Shooting was less effective and was often not an option due to the encroachment of residential development into agricultural areas. No farmers reported having their bird problems under control except for a single seed company with an intensive pest control program. The development of more effective and efficient methods for trapping birds or netting crops could make control of avian pests more cost effective. Currently, only large industrial farms can afford sufficient bird control measures such as propane cannons and bird watchers.

A pair of common mynas. *(Photo by K. W. Bridges)*

Recommendations

A multidimensional approach to reduce and prevent avian depredation would include habitat management, active removal of nonnative avian species in and near agricultural areas, agreement with hunting groups to stop the practice of game releases in agricultural areas, and preventing the spread of known agricultural pests among islands. Chemical repellents may prove necessary when these methods prove inadequate in protecting crops from avian depredation. Development of more cost-effective methods to control bird populations are desirable for farmers with fewer resources. Physical barriers such as fences around crops may be effective for gallinaceous birds, but their efficacy has not been tested. Diligence in the implementation of control measures is vital to successful control of invasive avian species in Hawaiian agriculture.

Farmers in Hawaii have been experimenting with new crops since the decline of sugar cane and pineapple crops. As birds discover these new crops and new avian populations become established, farmers can expect problems to become more severe with time. Farmers who do not currently have problems with bird depredation should be aware of the potential for depredation and should take preventative measures to keep birds from adapting to new food sources and becoming established in the area. Communication among farmers and land managers on this issue is very important.

Acknowledgments

We thank the farmers of Hawaii for participating in the survey and the Hawaii Farm Bureau for assisting in data collection. We also thank the following individuals for their input: R. Hirako, R. Hasegawa, P. Koehler, B. Pearson, and K. McMahon. Comments from M. R. Conover and 2 anonymous reviewers greatly improved this manuscript.

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Appendix 1. Copy of survey sent to 998 members of the Hawaii Farm Bureau, May 2004.

Name: _____

Affiliation (name of operation): _____

Mailing address: _____

Phone number: _____ **Email**: _____

1. Are you a farm owner, manager, researcher, or other position (please describe)?: _____

_____

Which island? _____ How long have you been farming? _____

2. Please list your crops, and the acreage of each: __

_____

3. How much do you spend each year to protect your crops from birds (including netting, scare tactics, field observers, etc.)?

_____

4. How much does bird damage cost you in lost production each year?

_____

5. What percentage of your total production is lost due to bird damage?

_____

6. How interested are you in new methods to repel birds from crops or to control their populations?

_____

7. What measures do you currently take (or have tried in the past) to control bird damage? Which ones were successful, which were not successful, and why? (write on back if necessary)

_____

_____

_____

_____

8. Please list (on the back) all the bird species that are a problem in your fields, orchards, or greenhouses and circle the top 5. If you are unsure about the species, place a question mark by your best guess and give us a brief description of the bird. A bird list has been provided for easy reference.

9. Any comments???

Marni E. Koopman is a research wildlife biologist with the USDA Forest Service Rocky Mountain Research Station in Fort Collins, Colorado. Most recently, she completed a project compiling survey and observation data on snowy plovers throughout their North American range in support of a planned comprehensive census in 2007. She completed her B.A. degree at the University of California–Santa Barbara, M.S. degree at University of California –Berkeley, and Ph.D. degree in ecology at University of Wyoming. Her research interests include metapopulation dynamics, connectivity and dispersal, molecular markers, and conservation ecology.

William C. Pitt is a wildlife research biologist and currently the station leader at the National Wildlife Research Center's Hilo, Hawaii Field Station. He completed a his B.S. degree at the University of Minnesota and his M.S. and Ph.D. degrees at Utah State University. His professional interests include invasive species management, predator–prey interactions, and animal behavior. He enjoys working with a broad array of wildlife, including mammals, reptiles, birds, amphibians, and arthropods.