Supporting Beneficial Birds and Managing Pest Birds

WILD FARM ALLIANCE

www.WildFarmAlliance.org

Acknowledgements and Background

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Since 2000, Wild Farm Alliance has educated farmers about on-farm biodiversity conservation, assisted them with its practical implementation, and initiated policies that support farm stewardship. Our mission is to promote a healthy, viable agriculture that protects and restores wild nature. Our work is centered on engaging and empowering those involved in the food and farming movement, including everyone from farmers to consumers.

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Table of Contents

Introduction

Birds can help you or your farm neighbor keep pest insects, rodents and pest birds at bay. Beneficial birds assist with production in the same way as beneficial insects. When you provide habitat for beneficial birds and bring them closer to your crops, you are increasing your pest control services.

Pest birds seem to get most of the attention these days, but that wasn't always the case. Researchers in this country and around the world are partnering with farmers to use new science and build on more than 130 years of past studies. These partnerships help us understand the roles birds can play in pest control and the relatively few but significant bird species that are pests themselves.

Today farmers who are masters at IPM—Integrated Pest Management—are using ecological pest-control strategies that include birds.

We think of certain birds as beneficials or as pests, but some species switch roles, depending on the season, their life cycles and the food sources available. Farmers can support these 'turn-coats' in the beneficial phases, and deter or co-exist with them at other times. Savvy growers manipulate habitat, and alter cultural practices and timing to take advantage of the benefits some birds provide and discourage damage from pest birds.

The overwhelming majority of songbirds are beneficial during nesting season because they feed pest insects to their voracious nestlings. Many songbirds continue to be beneficial throughout the year, but some switch to more plant-based diets in the fall, congregate in large flocks and become "pests."

But birds that consume fruit or nuts in season can later become beneficial to the farm again. In nut crops, for example, birds clean up the leftover "mummy" nuts that would otherwise harbor overwintering pests.

The overwhelming majority of songbirds, such as this Oak Titmouse, are beneficial during nesting season because they feed their nestlings insects.

Sometimes the effect of birds goes beyond what they eat. While raptors certainly prey upon rodents or pest birds in agricultural fields, the raptors' mere presence can also create a fear response in their prey, which can reduce crop damage.

Not surprisingly, growers tend to know a lot more about the birds that cause damage than about those that are beneficial. Losses can be significant for some crops, but the benefits of the pest control services provided by birds have not often been measured. Agriculture has functioned with birds for thousands of years. Some crop loss is inevitable and can be tolerated when it falls below the economic threshold. Diverse functioning farms make tradeoffs, and the multiple benefits of habitat that support bird life should be weighed against the drawbacks. Every situation is different. Farmers are constantly setting priorities and adapting management practices to existing conditions.

Accounts of Birds in Farm Fields

The following accounts are investigating effects of birds in pastures and crops grown in the Continental U.S. These stories reflect recent and historical scientific studies, and are the tip of the iceberg when it comes to bird-farm interactions.

Beneficial birds reduce pest insects, weeds, rodents, and pest birds. Creating and conserving habitat on the farm and in the surrounding landscape can support birds' pest-control efforts. Farmers are planting hedgerows and sunflower rows for habitat, and putting up nest boxes and perches to augment or replace habitat. The accumulation of these practices among growers, along with larger habitat conservation efforts of multiple stakeholders, increases the amount of habitat—and thus the number of birds that control pests—throughout agricultural landscapes. These accounts show that birds can reduce farm pests while increasing crop growth, yields, and/or cost-savings.

Legend for Types of Birds' Diets

- Omnivore
- Insectivore
- Carnivore
- Granivore

Birds Consuming
Pest Insects in Vegetables

Hedgerows in Kale Increase Pest Control

More Cabbage Looper caterpillars were consumed by birds near shrubby field margins than near other uncultivated areas. On average, caterpillars to which birds had access were reduced by 24%.[1] Yet, results suggested when the pests numbers were low, birds were not as effective.

In two separate kale studies, birds were beneficial in reducing caterpillars near shade trees; did not reduce aphids' natural enemies;[2] and reduced aphids and their leaf damage three times more than when birds were excluded.[3]

1 Garfinkel and Johnson 2015.
2 Guenat 2014; 3 Ndang'ang'a et al. 2013.

Natural Habitat Next to Cabbage Boosts Pest Control

Shrubby field margins, riparian areas and forest edges influenced a higher rate of aphid control through a combination of natural enemy birds and insects. Even though some birds consumed natural enemy insects, the overall effect on pest insects was beneficial for growers.[1]

In other cabbage studies, birds reduced more aphids in non-sprayed fields with higher abundance of the pests than in sprayed fields;[2] and reduced pest caterpillars by 49% in different fields.[3]

1 Martin et al. 2015.
2 Jadav et al. 2013; 3 Strandberg 1981.

Pest Control Increased Plant Growth in Broccoli

Birds reduced densities of two damaging caterpillars, resulting in increased plant growth. While other natural enemies were present, including spiders and parasitoids, birds were the most important predator.[1]

Another study reports birds increased aphids in broccoli by eating natural enemy insects later in the season, especially in simple landscapes. This did not impact yield, possibly because the late aphid leaf damage did not decrease head production.[2]

1 Hooks et al. 2003.
2 Smith et al. personal communication 2018.

Birds Consuming
Pest Insects in Nut Crops

Edges, Habitat, and Co-Existence in Almonds Can Yield Net Returns

Birds saved farmers on post-harvest costs of removing mummified almonds. While they also consumed marketable nuts, there was a positive net return of AUD $25–$275/hectare averaged across the orchards. More benefits occurred along orchard edges.[1]

In another study, birds, deer and rodents reduced Navel Orangeworm in organic and conventional orchards, more so in complex landscapes with higher proportions of natural habitat and a diversity of plants in the orchard understory.[2]

1 Luck 2014.
2 Eilers and Klein 2009.

Worthy Birds in Pecans

Each Tufted Titmouse is estimated to be worth about $2,900 to the pecan industry. Based on stomach contents, observations show that each bird consumes 2,100 pecan nut Casebearer larvae, and that 25 nuts could be destroyed by the offspring of one overwintering female insect. 52,000 nuts[1] would be saved at today's prices.[2]

An earlier study looking at the contents of bird stomachs found that 64 bird species ate these pecan pests: weevils, scale, beetles, termites and caterpillars.[3]

1 Whitcomb 1971.
2 At 45 shell nuts in a pound and at $2.50/pound.
3 McAtee, W. L. 1915 (in Tedders, 1983).

Walnut Orchards and Hedgerows Synergistically Support Pest Reduction

Birds killed an average of 41% of overwintering Codling Moths in walnut orchards.[1] Bark-gleaning bird species, such as woodpeckers and nuthatches, were the most prominent predators. Orchards with big old trees and hedgerow or riparian edges harbored more of these avian predators than young orchards with weedy margins. The amount of natural vegetation in landscapes surrounding orchards helped the most: Codling Moth consumption, mainly by birds, increased from 23% to 65% as natural vegetation increased from 0% to 38%.

1 Heath 2018.

Birds Consuming

Pest Insects in Fruit Trees

Habitat and Nest Boxes Influence Pest Control and Yields in Apples

Various studies reported that between 13% and 99% of overwintering Codling Moth in apple orchards were consumed by birds, especially near habitat.[1] When nest boxes were used to increase the density of Great Tits (a relative of chickadees), the apple yield increased by 66%.[2]

While pest birds cause damage, they often consume insects for part of the year (especially when raising their young), which can result in a net benefit, as one study showed.[3]

1 See Pest Insects in Apples in Appendix.
2 Mols and Visser 2002 and 2007.
3 Piesley et al. 2016.

Ground-Foraging Birds Diminish Pest Insects in Pears

When Dark-Eyed Juncos are in large flocks of 50 to 150 birds, they consume large numbers of insects. From 23,000 to 70,000 Pear Psylla females, with a potential production of 7 to 23 million eggs, were removed from orchard duff by the birds.[1]

In 1927, stomach contents of Black-Capped Chickadees, Golden-Crowned Kinglets and Red-Breasted Nuthatches were found to contain large numbers of psyllas in winter. The chickadees were attracted to the farm using suet and seeds.[2]

1 Fye 1982.
2 Odell 1927.

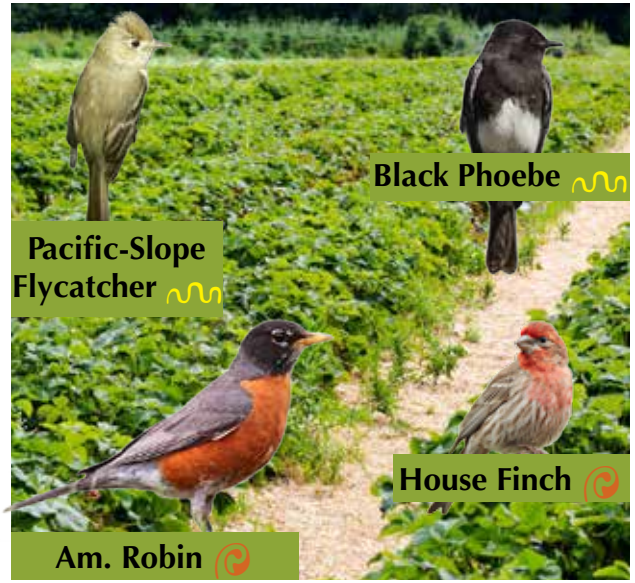
Tree- and Ground-Foraging Birds Lessen Pest Insects in Olives

Birds help reduce Olive Fruit Flies in two stages: larvae in the fruit and pupae on the ground. The olive fruit that was eaten by the birds mostly contained larvae,[1] suggesting that birds do not have a negative impact on production.[2] Birds consumed 65–71% of the pupae in soil, and ants attacked most of the rest.[1]

In other research, birds were one of several important predators of the Olive Fruit Fly pupae along with ants, beetles and centipedes.[3]

1 Bigler et al. 1986.
2 Pienkowski and Beaufoy 2000.
3 Cavalloro and Delrio 1975.

Birds Consuming
Pest Insects in Fruit Fields and Maple Sugar Bushes



Habitat in Strawberries Reduces Pest Bird Impacts

Beneficial birds decreased Lygus Bug damage at about the same rate as pest birds damaged the strawberry crop. Natural habitat in the surrounding landscapes and diversified farming practices promoted the most on-farm bird diversity. However, the highest abundance of pest birds was on farms surrounded by intensified agricultural landscapes. Farmers may benefit from diversifying farms in intensively farmed landscapes, and conserving semi-natural habitat at the landscape level.[1]

1 Gontheir et al. 2018.

Nest Boxes in Wine Grapes Increase Pest Control

Nest boxes greatly increased the abundance of Western Bluebirds and their ability to reduce insects in the vineyards. The highest removal of insects, 59%, was closest to nest boxes. DNA analysis of feces showed that birds were not consuming many natural enemy insects; only 3% were in their diet.[1]

In other studies, birds reduced insects about 33% more near nest boxes,[2] and they reduced up to 98% of insects on edges and interiors of vineyards.[3]

1 Jedlika et al. 2011 and 2017.
2 Benayas et al. 2017.
3 Howard and Johnson 2014.

Maple Syrup Is Doubly Sweet When Supporting Bird Biocontrol

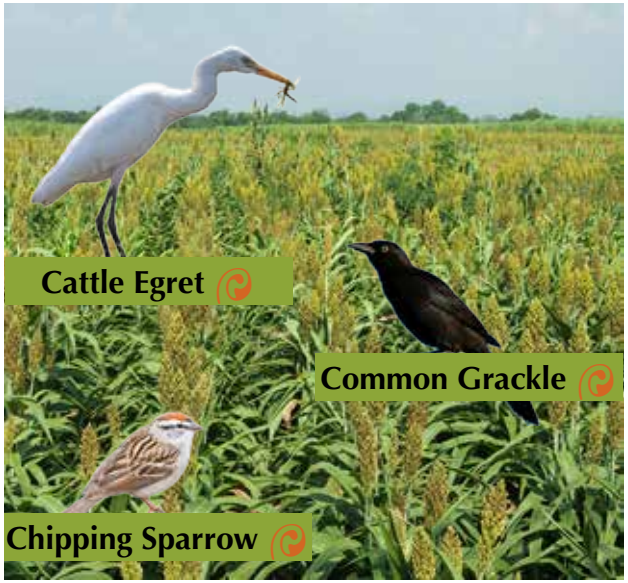
Birds reduced caterpillars by 17–37% over two years in maple forests. Sugar maple leaf damage was 15–35% less in the presence of birds, but this did not result in increased biomass production in the following year.[1]

In 1897–1898, a severe outbreak of forest tent caterpillars damaged thousands of acres of sugar maples.[2] Large numbers of warblers and other birds arrived and foraged on the catepillars in response. Audubon Vermont's bird-friendly label enrolls farmers in a marketing program to support bird conservation.

1 Strong et al. 2000.
2 Forbush 1908.

Birds Consuming

Pest Insects in Field Crops



Habitat Boosts Pest Control in Alfalfa

Songbirds reduced Alfalfa Weevils by over 33% on average. Fields with at least 2 trees along edges had over 13 species of birds, whereas fields with just weeds or dirt roads had only 5 species of birds. Increasing habitat greatly benefits over-wintering birds that provide pest-control services.[1]

Another study estimated that a flock of Swainson's Hawks ate 310,000 grasshoppers in 14 sq. miles of mostly alfalfa and corn, with adjacent small stands of trees.[2]

1 Kross et al. 2016a.
2 Johnson et al. 1987.

Habitat and Co-Existence in Corn Result in Pest Control

Birds reduced corn insect pests by 34–98% in various studies. Significant reductions in some cases were tied to nearby habitat patches that provided shelter for birds.[1]

Some of the beneficial birds were later pests. Co-existing with birds when they are beneficial, such as Red-Winged Blackbirds when they glean insects during corn's silking phase, can benefit the farm. Later in the year, management practices can be used to discourage their presence.[2]

1 See Pest Insects in Corn in Appendix.
2 Dolbeer 1990.

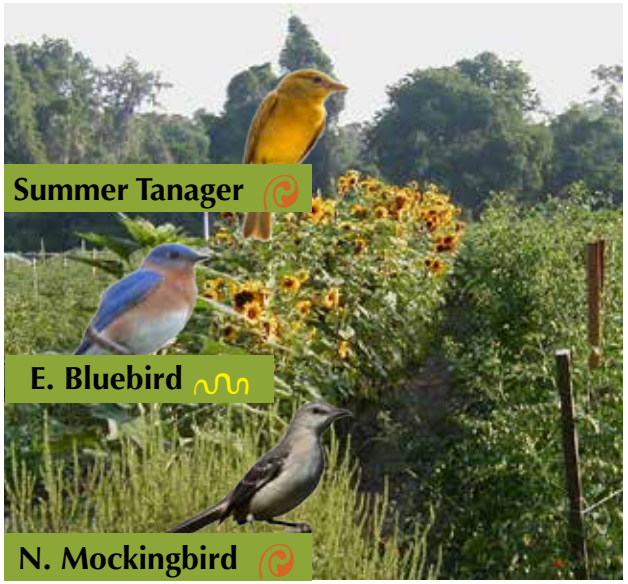
Modeling in Millet Predicts Pest Control

Birds were predicted to account for a reduction of 20–26% of grasshoppers in millet, according to modeling studies. This bird predation was estimated to reduce the following season's insect egg production by 34%.[1] Modeling helps make predictions based on previous findings.

In 1916, the examination of the stomach contents of more than 40 bird species present in millet and other grain crops contained evidence of the pest Armyworm.[2]

1 Axelsen et al. 2009.
2 Walton 1916.

Birds Consuming
Pest Insects in Field and Mixed Crops



Birds Help Curtail Pest Insects in Oilseed Rape

Examination of fecal sacs collected under active cavity and mud nests of aerial insect-eating birds contained 18–84% of pest insects. Some of these birds consumed the pest insects before the crop was harvested, as well as afterwards, impacting general pest populations.[1]

Another study found birds helped reduce oilseed rape pests, but were not be as important as other natural enemies. Bird presence was related to tree cover.[2]

1 Orlowski et al. 2014
2 Lemessa et al. 2015.

Co-Existence and Complex Landscapes Influence Pest Control

Birds shown above had 34–70% incidence of mostly cutworms in their stomachs, with the rest being wheat, grass and forb seed. Both species feed only insects to their young. In other studies bird predation on Corn Earworms in wheat was 34%, and on aphids was highest in organic wheat fields within complex natural landscapes.

Different research found no bird predation of aphids, possibly due to lack of bird perches. One study showed birds increased aphids by eating natural enemy insects, possibly because they were larger than aphids.[1]

1 See Pest Insects in Wheat in Appendix.

Sunflower, Sorghum and "T" Perches Reduce Insects

Live plant and "T" perches make it easier for birds to hunt insects. Chickpeas with perches versus pesticide trials gained higher net returns. Plant perches also supported parasitoids which additionally reduced the pests.[1] Compared to monocultures, mixed crops supported more insect-eating bird species that foraged for pests, and did not damage crops.[2]

In feeding trials using parasitized and non-parasitized Armyworms, birds strongly preferred the larger non-parasitized insects, leaving the next generation of natural enemies to hatch.[3]

1 Gopali et al. 2009.
2 Jones and Sieving 2006.
3 Jones et al. 2005a and 2005b.

Birds Consuming

Pest Insects and Weeds in Grasslands and Pastures

More than Beautiful Singers, These Birds Reduce Grasshoppers

Birds reduced grasshoppers by 25–55% in grasslands, preying selectively on different species and in different sites.[1,2,3] Foraging behavior of the birds was altered by the effects of drought, other predators, parasites, pathogens, and grazing intensity, which changed grasshopper distributions and influenced which patches the birds foraged. There is an interesting interplay between external forces defining grasshopper patches, and the dynamics of the bird predators with their prey.

1 Joern 1986 & 1992.
2 Fowler et al. 1991.
3 Bock et al. 1992.

Context Matters: When a "Pest" Bird is Beneficial in Pastures

European Starlings ate 40–60% of grass grubs in pastures, especially when pest abundance ranged from medium to high. Irrigation management and rotational grazing encouraged the birds to feed in infested paddocks. This combined strategy was effective in controlling grass grubs by preventing the population density from increasing above a level that affected spring pasture production.[1]

While starlings can be a pest at certain times in certain crops, they can also be beneficial.

1 East and Pottinger 1975.

Weed Seed Decreases in Pastures and Other Fields

Birds took 32% of the invasive Musk Thistle seeds in a pasture before they dispersed in the wind and on the ground. Animals and Weevils and other animals also destroyed the weed seeds.[1]

In other research, waterfowl reduced weeds in rice by 52%,[2] and also reduced weeds in cranberry and cotton fields. Weed seeds were found during many examinations of omnivorous bird stomachs. Weed seeds are an important food source when other foods are not available.[3]

1 Kelly and McCallum 1990.
2 van Groenigen et al. 2003; 3 Kirk et al. 1996.

Birds Consuming
Pest Birds

American Kestrel Nest Boxes Yield Big Savings in Cherries

Fruit-eating birds were significantly fewer in orchards with American Kestrel boxes. While kestrel nestlings typically were only fed 2% birds, the raptors' presence discouraged pest birds in the orchard. For every dollar spent on nest boxes, $84–$357 of sweet cherries may be saved from pest birds. Reduction of damage across the state of Michigan was estimated to result in $2.2 million to $2.4 million over five years.[1] Mowing to expose rodents is thought to increases raptors' effectiveness.

1 Shave et al. 2018.

Falcons Keep Pest Birds Guessing

Releasing wild falcons in New Zealand vineyards was estimated to decrease pest bird damage enough to result in savings of $234/hectare for the Sauvignon Blanc variety of grapes and $326/hectare for Pinot Noir. Actual numbers of pest birds were reduced by 78–83%, and grape damage by 55-95%.[1]

Some viticulturalists hire a falconer, which can be expensive, but besides the presence of the raptors themselves frightening the birds, they reinforce other scare tactics used to reduce pest-bird pressure.

1 Kross et al. 2012.

Perches Reduce Pest Birds in Vineyards

Aggressive Australian Magpies used perches and scared pest birds, reducing grape damage by >50%.[1] Raptors such as hawks did not use these artificial perches possibly because there were already enough trees and fence posts available for perching. Raptors such as falcons that rely on sight prefer high perches which give them the greatest visibility. Providing perches on a farm often increases raptors' presence and activity.[2]

1 Peisley et al. 2017.
2 Kay et al. 1994

Birds Consuming
Pest Rodents


Barn Owl


Red-Tailed Hawk


Red-Shouldered Hawk

Barn Owl Nest Boxes Are Cost-Effective

Over a three-year period, Barn Owls killed more than 30,000 rodents in one vineyard for a fraction of the cost of trapping or poisoning. The average cost of trapping was $8.11 per pocket gopher versus $0.34 per rodent taken by Barn Owls.[1]

Other research found Barn Owls are effective unless rodent populations are extremely high.[2] Owls prefer wooden boxes that are facing north, high off the ground and near grasslands.[3]

1 Browning et al. 2016.
2 Kross and Baldwin 2016.
3 Wendt and Johnson 2017.

Savings Garnered From Nest Boxes and Perches

An agency in charge of keeping levees structurally sound reported substantially less damage from ground squirrels and gophers in areas with Barn Owl nest boxes and raptor perches than in areas treated with rodenticides. They estimate a cost savings of $7,500 a year for each mile of levee.[1]

In other studies, increased avian predation significantly lowered crop damage by 20%, and was able to keep crop damage to less than 5%, which could lead to financial savings of up to $30/hectare/year.[2]

1 Novak et al. 2017.
2 Labuschagne et al 2016.

Perches Are Cheaper than Rodenticides in Reducing Rodents

Using raptor perches during a vole outbreak cost about 50% of the price of rodenticides. The perches, placed 5 per hectare, were as effective as poisons in reducing voles below economic injury level. Without perches, raptors did not increase markedly, even when the vole population was reaching its peak.[1]

Other studies showed that raptor perches were associated with reduced rodent population growth and density but not crop damage because rodent densities were so low,[2] possibly due to human activity.[3]

1 Machar et al. 2017; 2 Kay et al. 1994; 3 Askham 1990.

How Birds' Diets, Foraging Strategies and Nesting Periods Affect the Farm

Birds Can Eat Lots of Farm Pests

Birds reduce agricultural pests as shown in the above selection of bird accounts and in about 90% of the 118 avian pest control studies we've compiled (Appendix A). While it appears that birds might not help farmers avoid an epidemic pest outbreak, they do reduce pest numbers, especially during the breeding season, and can maintain low pest populations between epidemic outbreaks.

Birds have a high metabolic rate, which means they need to eat large amounts of food to survive. Globally, in agricultural areas such as crop fields, shelterbelts, and tree-lined field roads, birds eat about 28 million tons of insects per year, which accounts for 7% of their prey consumption (with about 70% coming from forests). About 200 pounds of prey per year were estimated to have been eaten by a pair of Barn Owls and their offspring in California, with prey including 843 gophers, 578 voles and 1540 mice.

Birds' Food and their Foraging Strategies

Diets

Insect-eating birds, or insectivores, consume mostly insects, occasionally eating seeds, fruits or leaves (see Table 1).

Where and How Birds Eat

Design your farm to support birds that use all these foraging strategies.

- Ground Forager: takes food items or pursues prey near or on the ground
- Stalking: ambushes or slowly pursues prey
- Foliage Gleaner: selects food items from leaves in the lower, middle and upper plant canopy
- Bark Forager: drills holes in or scales off bark
- Hovering: hovers in air while selecting prey
- Flycatching: perches on exposed branch, waits for insect to fly by, and then pursues insect in air
- Air Forager: flies after prey and captures it either in the air or on the ground
- Aerial Dive: dives for prey on the ground
- Soaring: gliding while scanning for prey

Evidence of a woodpecker foraging for and finding a Codling Moth coccoon on the bark of a tree.

Carnivores eat small mammals, reptiles, amphibians, and other birds. Nectivores consume nectar.

Omnivores consume both plants (including fruits and nuts) and animals (including insects). Granivores are seed eaters. Frugivores eat mainly fruits, but very few live in North America. It is the Omnivores and Granivores that can switch from being beneficial (eating pest insects and/or weed seeds) to pests (eating the produce or grain).

Foraging strategies

Most birds do not tend to specialize on one species of insect or rodent. Rather they are apt to eat a range of prey, depending on their feeding strategies and the defense behaviors of their prey. Whether birds catch insects in the air, glean them from foliage or bark in the upper or middle canopy, or capture them on the ground will result in different types of pest control benefits. Having an assortment of birds with different foraging techniques and diets will better reduce the suite of pests on the farm.

Bigger Food Is Better

Consuming large insect prey that quickly satiates birds and their nestlings is a priority, because it leaves them with more energy for additional foraging and successfully raising their brood. In some cases, birds have also taken the larger natural-enemy insects and spiders that farmers treasure, instead of small aphid prey. Three percent of the studies in Appendix A showed that birds killed natural enemy insects enough to constrain pest control.

Birds Smell Pest Insects Feeding

Bird are mobile and can quickly respond to a pest outbreak. Sometimes birds can locate their prey by using their sense of smell. For example, when plants are being attacked by insects, they can emit a chemical that birds recognize, helping the birds quickly and efficiently forage for the pests. The higher the density of the prey—whether insects or rodents—the more attractive an area is to birds.

Sorting Out Who's Who in the Bird World

Just as different livestock use a farm's food and shelter resources in distinct ways based on their unique characteristics, so do birds. Each bird species is unique in what, how and where they eat, how they raise their young, whether they migrate, and where they spend their winter months. All of these behaviors influence what the birds do on the farm, and how farmers can support and/or manage them (see Table 1).

Habitat Influences

Pest control by birds often occurs next to habitat. Of the 60 studies mentioned in Appendix A that measured the influence of habitat (39 plant habitat and 21 artificial nest boxes and perches), about 95% reported that pest control by birds occurred especially when habitat was nearby. It is not surprising that birds are associated with habitat. Just as we need safe houses to live in and healthy food to eat, habitat offers birds those same necessities. Habitat supports birds on the farm in two major ways. The first is physical: habitat creates a framework for perching, roosting, nesting, cover (protection from adverse weather and predators), and travel corridors. The second is nutritional: habitat also offers nutrition to birds in the form of seeds, berries and insects. When habitat provides diverse structure and composition, it attracts a more abundant and diverse community of birds.

Table 1a. Supporting and Co-Existing with Birds

Practice Co-Existence with These Birds During Nesting Season

With farming, there is a balance of gains and losses. Integrated pest management uses natural enemy insects and beneficial birds to combat pest insects and birds in similar ways. For example, in order to have natural enemy insects present, native plants are used to support not just these beneficials but the pest insects they eat. Sometimes the only option is to use a row cover fabric to protect the plants from pest insects. The same is true with birds. Beneficial birds are attracted to the farm with habitat and will consume pest insects present. Non-cash crops or bird seed can lure pest birds away from the crop, and with a few crops, the best option is to use netting. Many birds are beneficial year-round, while others are beneficial during the nesting season when they feed insects to their young, but may need to be managed later on depending on the bird and the crop grown. Co-existence should be practiced with these birds. Tables 1a and 1 b contain many of the birds found in the US that have been the subject of pest control research or are known to be beneficial.

Omnivores/Granivores

Bird Family/Species		Foraging Strategy
Quail Family		
◆	California Quail	Ground
Crow Family		
■ ⊛	California Scrub-Jay	Ground
■ ✓	Yellow-billed Magpie	Ground
● △ ■ ⊛	American Crow	Ground
Lark Family		
✓	Horned Lark	Ground
Mockingbird Family		
	Northern Mockingbird	Ground
	Brown Thrasher	Ground
Starling Family		
●△□ ■ ⊛	European Starling	Ground
Pipit Family		
	American Pipit	Ground

Bird Family/Species		Foraging Strategy
Sparrow Family		
◆	White-crowned Sparrow	Ground
	Song Sparrow	Ground
	Savannah Sparrow	Ground
	Chipping Sparrow	Ground
✓	Grasshopper Sparrow	Ground
	Cassin's Sparrow	Ground
	Lark Sparrow	Ground
△ □	House Sparrow	Ground
✓	McCown's Longspur	Ground
	Dark-eyed Junco	Ground
Cardinal Family		
	Northern Cardinal	Ground
	Black-headed Grosbeak	Foliage Gleaner
	Painted Bunting	Ground

Bird Family/Species		Foraging Strategy
Oriole and Blackbird Family		
	W. & E. Meadowlark	Ground
● ■	Brewer's Blackbird	Ground
●	Red-winged Blackbird	Ground
	Yellow-headed Blackbird	Ground
	Common Grackle	Ground
	Orchard Oriole	Foliage Gleaner
	Bullock's Oriole	Foliage Gleaner
Finch Family		
● ◆	House Finch	Ground
	American Goldfinch	Foliage Gleaner
	Pine Siskin	Foliage Gleaner
Thrush Family		
● ⊛	American Robin	Ground

Legend for Co-Existence

● When in grapes, cherries or blueberries, netting or falconry may be needed.
△ Sometimes associated with foodborne pathogens.
□ Beneficial in some situations, this non-native is generally discouraged.
■ Will consume crop before harvest and also eat mummies after harvest.
⊛ Discourage from pecking fruit and drip tape by providing water source.
◆ Discourage from eating seedlings by supplemental feeding of seed, providing alternate crop, or placing a buffer between crop and habitat.
✓ Declining in numbers and are of conservation concern.

Table 1b. Supporting and Co-Existing with Birds

Encourage These Birds Year-Round

Insectivores

Bird Family/Species		Nest Type	Foraging Strategy
Plover Family			
	Killdeer		Ground
Woodpecker Family			
	Red-breasted Sapsucker		Bark
	Nuttall's Woodpecker		Bark
	Downy Woodpecker		Bark
	Hairy Woodpecker		Bark
⊛	Northern Flicker	Nest Box	Ground
Flycatcher Family			
	Pacific-slope Flycatcher		Flycatching
	Ash-throated Flycatcher	Nest Box	Flycatching
	Black Phoebe	Eaves	Flycatching
	Say's Phoebe	Ledges	Flycatching
	Western Kingbird	Ledges	Flycatching
Swallow Family			
	Barn Swallow	Structures & Ledges	Air
	Cliff Swallow	Eaves	Air
	Violet-green Swallow	Nest Box	Air
	Tree Swallow	Nest Box	Air
Chickadee Family			
	Black-capped Chickadee	Nest Box	Foliage Gleaner
✓	Chesnut-backed Chickadee	Nest Box	Foliage Gleaner
✓	Oak Titmouse	Nest Box	Foliage Gleaner
	Tufted Titmouse	Nest Box	Foliage Gleaner

Bird Family/Species		Nest Type	Foraging Strategy
Bushtit Family			
	Bushtit		Foliage Gleaner
Creeper Family			
	Brown Creeper		Bark
Nuthatch Family			
	White-breasted Nuthatch	Nest Box	Bark
	Red-breasted Nuthatch	Nest Box	Bark
Wren Family			
	Pacific Wren		Ground
	Bewick's Wren	Nest Box	Foliage Gleaner
	House Wren	Nest Box	Foliage Gleaner
Kinglet Family			
	Golden-crowned Kinglet		Foliage Gleaner
	Ruby-crowned Kinglet		Foliage Gleaner
Gnatcatcher Family			
	Blue-gray Gnatcatcher		Foliage Gleaner
Thrush Family			
	Western Bluebird	Nest Box	Flycatching
	Eastern Bluebird	Nest Box	Ground
Wood Warbler Family			
	Black-throated Grey Warbler		Foliage Gleaner
✓	Wilson's Warbler		Foliage Gleaner
Tanager Family			
	Summer Tanager		Foliage Gleaner

Carnivores

Bird Family/Species		Nest Type	Foraging Strategy
Heron Family			
	Great Blue Heron	Structures	Stalking
	Great Egret	Structures	Stalking
	Cattle Egret		Stalking
Hawk Family			
	Northern Harrier		Aerial Dive
	Cooper's Hawk		Air
	Red-tailed Hawk	Ledges	Soaring
	Red-shouldered Hawk		Aerial Dive
	Sharp-shinned Hawk		Aerial Dive
	White-tailed Kite		Hoovering
	Swainson's Hawk		Soaring
Falcon Family			
✓	American Kestrel	Nest Box	Aerial Dive
	Merlin		Air
Owl Family			
	Great Horned Owl	Structures	Aerial Dive
	Barn Owl	Nest Box	Aerial Dive
	Northern Saw-whet Owl	Nest Box	Aerial Dive
Shirke Family			
✓	Loggerhead Shrike		Aerial Dive
	Northern Shrike		Aerial Dive
Vulture Family			
	Turkey Vulture		Soaring

The birds in Table 1b are categorized by what they predominately eat.

Native Plants Provide More Food Value

If birds are to successfully raise a clutch of young, they require a steady food source composed mostly of insects. Even those birds that will later eat fruit and nuts feed insects to their nestlings.

Native plants attract birds onto the farm for the insects and structure they provide. Native plants can supply much more insect diversity and abundance than non-native plants. For example, over 500 species of caterpillars were found on native oak trees studied in the Mid Atlantic region of the U.S. Chickadees strongly prefer to forage in native plants that support the most caterpillars. Using native habitat to attract birds to farms will increase the chance that they will be readily present to scout for emerging pests within fields as well.

Habitat on the Farm

Simplified landscapes without natural habitat that are commonly seen in agriculture (e.g., extensive monocultures) may be one reason that pest control by birds is not more well-documented. Nevertheless, it sometimes does not take much effort to improve farms for birds and to potentially increase their pest control services. For example, as few as two trees present on the edges of alfalfa fields increased bird numbers and their insect pest consumption.

Many forms of habitat patches—from orchard understories and sunflower and sorghum perches, to shrubby edges, hedgerows, windbreaks, trees, riparian areas and upland woods—can influence birds' pest-control services in crops. Nest boxes, perches and structures on buildings can attract insectivorous birds and raptors. Often the birds' benefits to the crop are seen closer to the habitat provided (see Appendix A).

Native plant hedgerows can be located on the borders of fields, along roads or in other uncropped areas.

Native plants are better support than nonnative plants for birds like this female Western Bluebird, which has captured an insect in this native oak tree.

Management of farm fields together with habitat patches and artificial structures will support the most birds. Other techniques to conserve birds on farmland include smaller field sizes with edge habitat; farmsteads with non-crop habitat and pastures; more permanent crop covers such as winter grains and orchards; fewer tractor passes and tilling; and less use of herbicides and chemical fertilizers.

Hedgerows, tree lines and remnant riparian habitat support more bird abundance and diversity than bare or weedy margins. Planting this habitat on farms surrounded by simple landscapes gives the most bang for the buck when it comes to increasing bird presence, whereas adding habitat to farms already surrounded by very diverse landscapes does not increase bird numbers as much. In these complex natural landscapes bird numbers are often already high, but providing habitat on any farm will still lead to an increase in bird abundance and diversity.

Habitat in the Surrounding Landscape

Complex landscapes such as forests can strongly influence the presence and actions of birds and other organisms on a farm. These landscapes can increase the abundance and diversity of birds and their pest-control services (see Appendix A). For example, in California walnut orchards, both woodpecker abundance and Codling Moth predation was much higher in landscapes with more natural vegetation. At least 11 other studies have similarly measured pest reduction by birds in relation to the amount of natural habitat in the larger landscape — four showed that bird predation of crop pests was highest in landscapes with more natural habitat, while the remaining studies found little to no effect of the surrounding landscape. A global analysis of many different types of natural enemies similarly found that there is no one-size-fits-all answer to this very interesting question.

Nesting Territories, Boxes and Structures

Birds are very territorial when it comes to staking their claim to optimal nesting sites. As each bird species searches for a place to nest, they are seeking certain habitat features that are rich in their preferred food sources, provide hiding places for their nests, and have few predators that could attack their nestlings. Larger birds tend to need bigger territories to raise their young. While establishing their territories, birds are also trying to attract mates, and later one or both will construct the nest.

Nest building can take many forms, from woven cups and pendants, to cavities and platform structures. Farmers can provide nesting habitat for several beneficial birds. Cavity nesters will be attracted to nest boxes, since they evolved to use similar hollows in trees, crevices in rocks, and burrows in the ground. Likewise, birds that build their nests on structures are attracted to using artificial ones as substitutes for the real thing (see Table 1).

Tree cavities provide nesting sites for birds.

Predators, Sound and Cover

Birds are always watching out for predators, flicking their heads back and forth, searching for danger. Birds also pay attention to sounds. Some chickadees and their relatives, such as Tufted Titmouse, listen for the pattern of "chick" and "dee" notes in their chick-a-dee calls to alert them to danger. More "dee" notes indicate a threat. They listen and watch what other birds are doing. Hearing the quiet of no calls, or seeing a quick scattering or swooping up and away, can alert them to a predator. Songbirds that consume pest insects may be hesitant to dart very far from habitat when manmade or natural raptor perches are present.

Timing Is Everything

Birds may or may not be around when the farm needs them. Some are resident, meaning they live year-round in the same place. Others are migratory, spending part of the year nearby and the rest elsewhere. Migrations may be short (such as a change in elevation), medium (such as a couple of states away) or long (such as between the U.S. and north to Canada and Alaska, or south to Central or South America). Some will only be present on the farm in the winter and others only in the summer.

So, if an insect-eating bird is present in a walnut orchard in the winter and gleans insects from tree bark, it will likely consume Codling Moth larvae. Supporting songbirds in the spring and early summer with a hedgerow near a kale crop can result in them feeding lots of pest insects to their young. However, if a rodent- and bird-eating raptor is only present in wine grapes in the spring, but pest birds are a problem in the fall when the crop matures, the timing is off, and the raptor might not be as beneficial to the farm as the farmer had hoped. In general though, the more the farm can support birds for their year-round feeding, their nesting or spring and fall migrations, the more diversity of birds will be present to help with pest control.

When a raptor like this Red-Shouldered Hawk is around, the chattering of birds ceases, and that "deadly quiet" alerts all wildlife of danger.

How Best to Manage and Co-Exist with Pest Birds

While growers tend to focus on the birds that cause problems, not all birds are bad. Site-specific management of pest birds is required for some crops, usually when the crop is at peak ripening or tender seedling stages.

Complete protection of crops is hard to achieve. While California growers do use various strategies, the state's commodity crops suffer annual losses of $168–$504 million due to birds and rodents. In Michigan, losses from birds alone were estimated to be $38 million annually. Some of the hardest hit crops are blueberries, cherries, wine grapes, and apples. A grower survey conducted on these crops in five states (California, Michigan, New York, Oregon, and Washington) reported that European Starlings, "Blackbirds," American Crows, American Robins, and Wild Turkeys were the most commonly implicated birds causing damage. In other reports, Blackbirds and birds in the Corvid family—Common Ravens, American Crows, Western Scrub Jays, and Magpies—cause large losses to ripening corn, and sometimes to rice, wheat and other grains as well as seed and nut crops.

Practicing Co-Existence When Possible

When growers make management plans, they should consider whether these pest birds may be beneficial at various production times. In grapes, for example, birds' pest control services should be taken advantage of throughout the year, except during those weeks when the crop may be eaten by the birds. The same is true for orchard crops, not just because the birds eat insects directly, but also because they remove mummy fruit and nuts that harbor pest insects and diseases (see Dos Aguilas Olive Farm story).

Why Conserve Habitat Instead of Removing It?

The prevailing notion that habitat only brings problems is outdated. There are good reasons to conserve habitat for natural enemy birds and insects.

While pest birds as well as beneficial birds will be present in hedgerows, pest birds are usually also found throughout the crop in the same numbers as in the hedgerows, hence hedgerows do not necessarily increase the birds' abundance. In fact, American Crow, Red-winged Blackbird and Brewer's Blackbird (which are at times both beneficial and pests) were present five to ten times more in the winter and spring in farm fields that did not have hedgerows.

Hedgerows, windbreaks and other field margins usually do not serve as significant breeding habitats for pest birds, although in some site-specific cases, damage from pest birds has been associated with edge habitat. Whether those same pest birds were beneficial at other times of the year is not known. Benefits and costs should be weighed when introducing or retaining habitat, which also supports pollinators, natural enemy insects and erosion control, fosters water quality and infiltration, and provides wind protection and dust barriers.

The most damaging pest birds occur in large flocks, and these prefer to forage in open areas within field interiors (away from habitat). These flocking birds avoid predators by being one of many in the flock, making it hard for predators to pinpoint and kill any one of them. Additionally, large flocks of pest bird species fly long distances from big roosting sites to the crop, rather than using

With a beak full of insects, this female Red-winged Blackbird proves its worth in the spring when feeding its nestlings. Later in the year co-existence may need to be practiced if it also consumes a crop.

smaller, localized farm habitat. Single birds or small flocks of birds, such as White-crowned Sparrows, may cause damage to the first couple of rows of certain crops, but these problems are minor, or can be controlled. Each situation is unique and depends on crop, timing, habitat availability in the landscape, and the species present.

Management Steps to Take

Making Plans for Scouting and Flexible Management

Long before the pest birds arrive, a management plan suited to the farm and the neighboring lands should be in place. Once the birds are eating the crop, they are much harder to discourage. This plan includes scouting for the presence of birds and using several types of deterrents. Scouting should begin before the crop is ripe (possibly when it is still green) and continue through the harvest. Birds are often most active in the early morning or around dusk, so scouting at those times can give a good indication of the bird pressure.

It is important to attempt to identify the species you see (to determine if they are potential pests as listed in Table 1a) and to observe the birds for signs of whether they are damaging the crop or actually consuming pest insects. Sometimes it is easy to assume that birds in a ripening field are there to consume the crop, but in some situations they may be there to hunt for insects that are attracted by the ripening crop. If the birds are causing damage, the numbers of pest bird individuals and species present can help inform the level of intensive protection that would be required. Some crop fields may be more attractive to birds because they contain a certain variety or because of their location in the landscape. Other fields may be limited in what kinds of management can be used because of human neighbors sensitivity to loud noises or firearms. In low-yield years, more management may be required to protect the crop. Figure 1 shows how this information can be used to determine how much should be spent on discouraging birds. Using adaptive management strategies based on scouting levels and crop and site characteristics will result in a more successful protection plan. Keeping records of the various control methods used and their costs can help determine if they are worthwhile.

Scaring Birds

Frightening devices are most often used by growers but may not be very effective. The main problem with using scaring tactics is that the birds habituate to most methods quickly. In order for scaring to work, it needs to be unusual, unexpected or unfamiliar, and be perceived by birds to put them in real jeopardy.

Scaring strategies can sometimes cause damage to the crop. One reason is a loud noise or visual "cue" used to discourage pest birds may have the opposite effect and attract them instead. Similar to a dinner bell, loud noises may signal that the crop is ready to eat. Continually scaring birds keeps them on the move, which increases their energy demands, making them eat more. Additionally, a scared bird may drop the food in its mouth, only to return later to feed on fresh food.

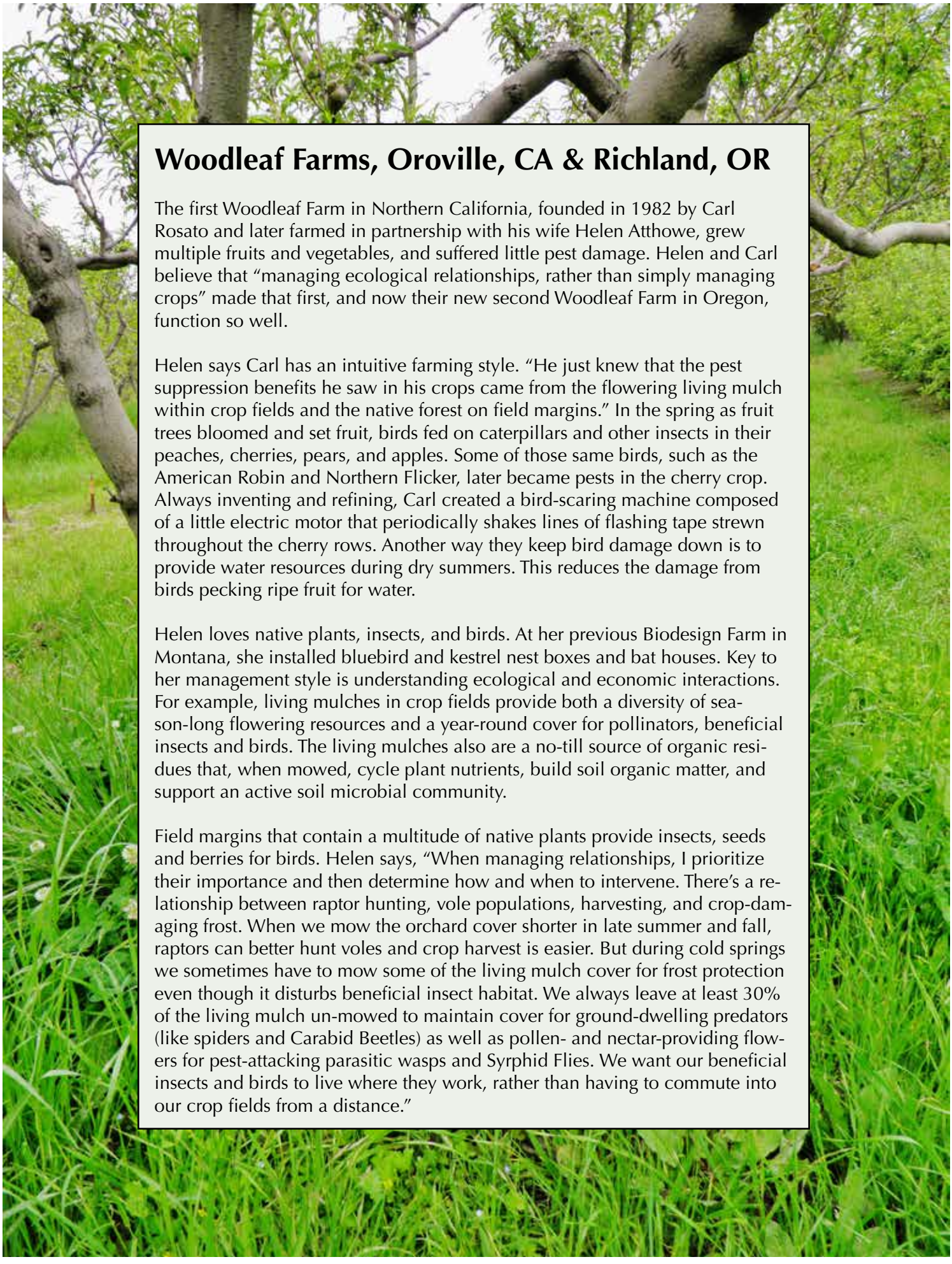
Figure 1. Calculating the Value of Pest Bird Management Strategies

Effectiveness of Treatment (reduction in loss to birds)

Loss to Birds	25%	50%	75%	100%
5%	<$125	<$250	<$375	<$500
10%	<$250	<$500	<$750	<$1000
20%	<$500	<$1000	<$1500	<$2000
30%	<$750	<$1500	<$2250	<$3000

Growers can use this chart to determine how much they should spend on discouraging birds. For example, if you gross $10,000 per acre in wine grapes, losing on average about 5% to birds, and you are trying to decide how much to invest in a tactic that is about 25% effective, this chart tells you that you shouldn't spend more than $125 per acre.[1]

[1] After Spurr and Coleman 2005, with modifications by C. Heidenreich at Cornell University and by Washington State University Whatcom County Extension.



Woodleaf Farms, Oroville, CA & Richland, OR

The first Woodleaf Farm in Northern California, founded in 1982 by Carl Rosato and later farmed in partnership with his wife Helen Atthowe, grew multiple fruits and vegetables, and suffered little pest damage. Helen and Carl believe that "managing ecological relationships, rather than simply managing crops" made that first, and now their new second Woodleaf Farm in Oregon, function so well.

Helen says Carl has an intuitive farming style. "He just knew that the pest suppression benefits he saw in his crops came from the flowering living mulch within crop fields and the native forest on field margins." In the spring as fruit trees bloomed and set fruit, birds fed on caterpillars and other insects in their peaches, cherries, pears, and apples. Some of those same birds, such as the American Robin and Northern Flicker, later became pests in the cherry crop. Always inventing and refining, Carl created a bird-scaring machine composed of a little electric motor that periodically shakes lines of flashing tape strewn throughout the cherry rows. Another way they keep bird damage down is to provide water resources during dry summers. This reduces the damage from birds pecking ripe fruit for water.

Helen loves native plants, insects, and birds. At her previous Biodesign Farm in Montana, she installed bluebird and kestrel nest boxes and bat houses. Key to her management style is understanding ecological and economic interactions. For example, living mulches in crop fields provide both a diversity of season-long flowering resources and a year-round cover for pollinators, beneficial insects and birds. The living mulches also are a no-till source of organic residues that, when mowed, cycle plant nutrients, build soil organic matter, and support an active soil microbial community.

Field margins that contain a multitude of native plants provide insects, seeds and berries for birds. Helen says, "When managing relationships, I prioritize their importance and then determine how and when to intervene. There's a relationship between raptor hunting, vole populations, harvesting, and crop-damaging frost. When we mow the orchard cover shorter in late summer and fall, raptors can better hunt voles and crop harvest is easier. But during cold springs we sometimes have to mow some of the living mulch cover for frost protection even though it disturbs beneficial insect habitat. We always leave at least 30% of the living mulch un-mowed to maintain cover for ground-dwelling predators (like spiders and Carabid Beetles) as well as pollen- and nectar-providing flowers for pest-attacking parasitic wasps and Syrphid Flies. We want our beneficial insects and birds to live where they work, rather than having to commute into our crop fields from a distance."

Visual

Periodically moving scarecrows and fake predators can enhance their effect on birds. Other visual scare devices include bird kites, and reflective tape that moves in the wind or is attached to strings pulled by a motor (see Woodleaf Farms story). Lasers are starting to be used to discourage birds, but for now it is very costly and research is lacking on whether the beams can cause long-term harm to birds.

Sound

In order for sound to work, it should be presented at irregular intervals and the source should frequently be moved to different locations. Sound devices include gas guns, bird distress calls, predator calls, and ultrasonics. More mobile scare tactics include workers patrolling on ATVs with noise-makers, and the use of drones that imitate the sound and flight of natural predators. Using both visual and sound tactics generally is more effective than either on their own.

Nest Boxes and Perches

Artificial structures that serve as replacements for natural nesting cavities can support raptors that discourage pest birds. In Michigan, American Kestrel nest boxes in cherry orchards reduced pest birds, increasing yield by $2.2-2.4K for the state over five years. These boxes cost about $115 each to install and $23 to maintain on a yearly basis. In Australia, perches used by Magpies in wine grapes discouraged the presence of fruit-eating birds, and lessened damage by 50%. The pest birds in both cases were scared away by the aggressive birds, rather than eaten by them.

Falconry

Using falcons to protect crops will inspire instinctive terror in pest birds. The falcons are not killing the marauders. Instead, their presence reinforces other scare tactics used by the grower. Large and small farms are hiring falconers with abatement permits. Smaller operations can share falconer's fees with their neighbors. Hiring a falconer costs on average about $600 per bird per day. If a falcon is only needed for a couple of weeks for the complete operation when the crop is attractive to pest birds, such as in some wine-grape growing regions, the costs may be relatively affordable. In other wine-growing regions, however, falcons may be needed for more than six weeks. The amount of area a falcon can cover depends on the topography of the landscape. For example, one falcon can patrol a 900-acre rectangular vineyard that is gently sloped in one direction making it easy to see the whole place, whereas one falcon can only cover 500 acres of a ranch with undulating terrain and oak trees. Although falconers were not hired, the power of falcon presence was measured after rare, resident falcons had been relocated from their nests in mountains of New Zealand to vineyards. The NZ falcons discouraged European Starlings, Song Thrushes and Blackbirds, as well as a native species of Silvereyes, reducing crop damage by roughly 68%. Cost savings ranged from $234 to $326/hectare depending on the grape varietal.

Discouraging Pest Birds with Cultural Practices

Exclusion from the Crop

Of all the pest-bird management strategies, exclusion works best. Netting can be very expensive to purchase and it is time consuming to put up and take down every year, which means additional cost. However, where there is heavy bird pressure, it may be warranted. Before using netting, consider the costs and durability over time versus the amount of damage caused by birds. If a decision is made to purchase netting, spacers may be needed to keep birds from pecking through the nets. Besides the downside of expense, netting can alter light and air flow, and can be troublesome to work around.

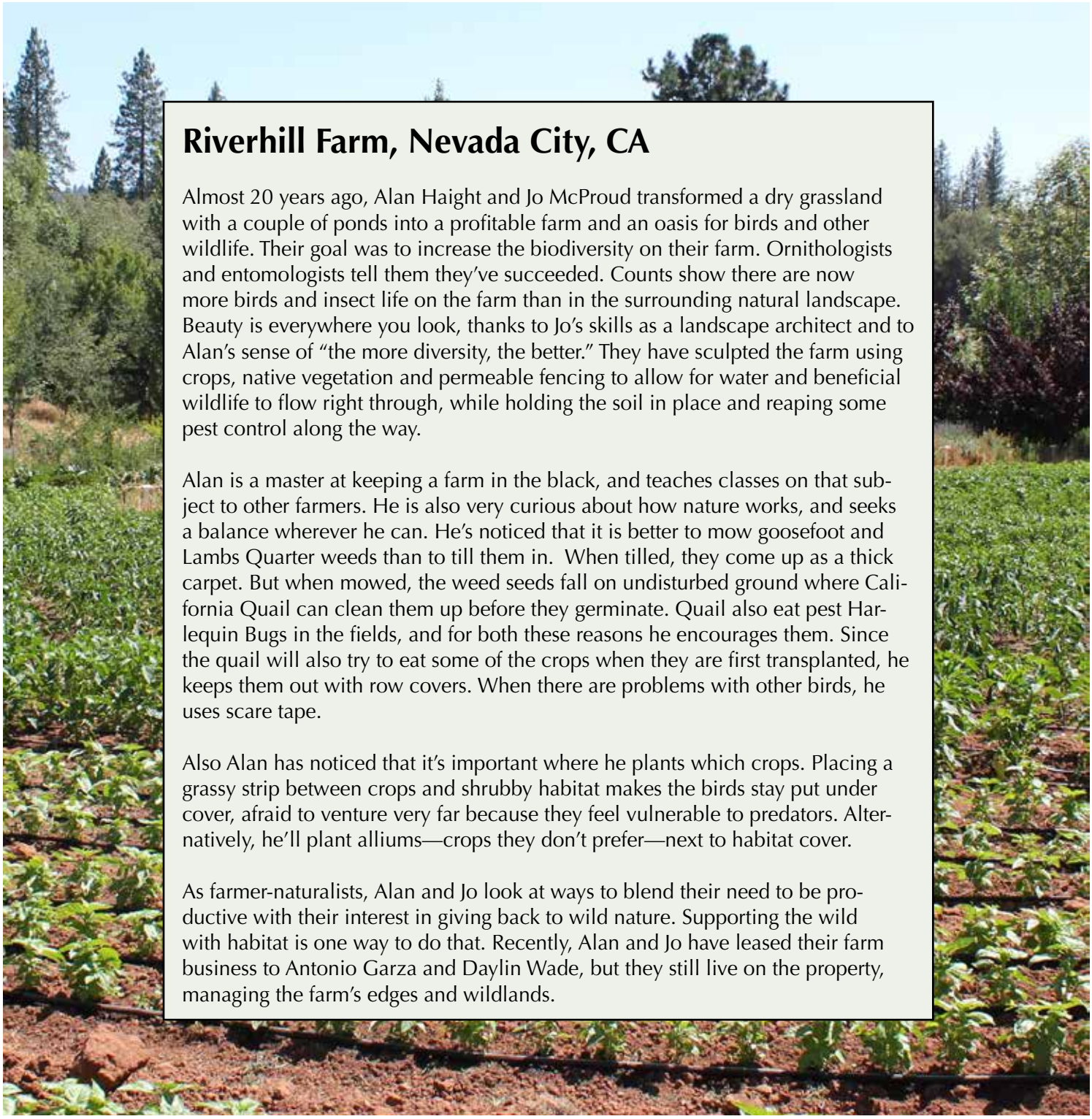
Growers also use floating row cover fabric to protect crops from bird damage. According to some, if they leave the row cover on all season, rodents have been known to increase because the cover limits access of raptors and other predators.

Placing a Buffer Between the Crop and Habitat

To discourage birds from damaging the first few rows of a crop next to habitat, some growers reserve the strip between the crop and habitat for grass or dirt road buffers or for crops the birds will not eat. Since these birds are using the habitat for cover from predators, they are reluctant to venture far from it (see RiverHill Farm story).

Attracting Birds Away from Crop

Farmers and scientists have found that damage by pest birds can be lessened by feeding them. Growers reduce damage to young crops planted next to natural habitat by letting the first few crop rows go to seed. This could allow birds to forage on a few rows and dissuade them from venturing out to forage on the rest of the crop (see Fresh Run Farm story). Other ways to reduce damage to a target crop include offering alternate feeding sites, such as leaving oat and wheat stubble, or leaving unplowed early-harvested sweet corn while later-maturing corn is ripening. Providing cover crops that Sparrows prefer over the commercial crop may reduce the incidence of damage to plants in the Cole crop family.



Riverhill Farm, Nevada City, CA

Almost 20 years ago, Alan Haight and Jo McProud transformed a dry grassland with a couple of ponds into a profitable farm and an oasis for birds and other wildlife. Their goal was to increase the biodiversity on their farm. Ornithologists and entomologists tell them they've succeeded. Counts show there are now more birds and insect life on the farm than in the surrounding natural landscape. Beauty is everywhere you look, thanks to Jo's skills as a landscape architect and to Alan's sense of "the more diversity, the better." They have sculpted the farm using crops, native vegetation and permeable fencing to allow for water and beneficial wildlife to flow right through, while holding the soil in place and reaping some pest control along the way.

Alan is a master at keeping a farm in the black, and teaches classes on that subject to other farmers. He is also very curious about how nature works, and seeks a balance wherever he can. He's noticed that it is better to mow goosefoot and Lambs Quarter weeds than to till them in. When tilled, they come up as a thick carpet. But when mowed, the weed seeds fall on undisturbed ground where California Quail can clean them up before they germinate. Quail also eat pest Harlequin Bugs in the fields, and for both these reasons he encourages them. Since the quail will also try to eat some of the crops when they are first transplanted, he keeps them out with row covers. When there are problems with other birds, he uses scare tape.

Also Alan has noticed that it's important where he plants which crops. Placing a grassy strip between crops and shrubby habitat makes the birds stay put under cover, afraid to venture very far because they feel vulnerable to predators. Alternatively, he'll plant alliums—crops they don't prefer—next to habitat cover.

As farmer-naturalists, Alan and Jo look at ways to blend their need to be productive with their interest in giving back to wild nature. Supporting the wild with habitat is one way to do that. Recently, Alan and Jo have leased their farm business to Antonio Garza and Daylin Wade, but they still live on the property, managing the farm's edges and wildlands.

For sunflowers in the Prairie Pothole Region, which can be hard hit by Blackbirds, providing supplemental sunflower plots for them to eat may lessen the damage to the crop you are trying to protect. To help attract the birds away from the commercial crop, growers can plant the plots: a) near the birds' cattail night roosts, b) near trees not adjacent to the commercial crop, c) earlier than the commercial crop to get the birds used to feeding there, and d) with a mix of sunflowers that mature differently.

Adjusting Planting Times and Crop Cultivars

In crop areas where pest bird pressure is heavy, growers can synchronize their plantings with those of their neighbors so that they harvest at the same time, reducing damage that otherwise might have occurred with early or late harvests.

Scientists have developed bird-resistant cultivars for some grain crops, including corn, sorghum, rice and

sunflowers. These cultivars have traits such as heavier husks that make it difficult for birds to penetrate; more flexible stems that make it harder for birds to perch and feed; larger seeds that are hard for smaller birds to eat; or concave and down-turning heads that make it harder to remove seed. Bird-resistant traits worked best when alternative sources of preferred bird food were present.

Chemical Repellents

Chemical agents may work to repel birds, but may also repel consumers because of taste issues, as is the case for wine grapes. Chemical repellents have met with poor success in sunflowers and pistachios. Only products registered for the crop and applied by certified Pesticide Control Applicators can be used.

Blocking Pest Bird Access to Farm Buildings

Nonnative European Starlings and House Sparrows often nest near and/or in houses, barns and others structures using vents, eaves, gutters and downspouts. These can be blocked using half-inch wire mesh or more solid wood or metal materials. Netting can be used on the undersides of rafters to prevent birds from roosting and nesting there. This may be especially important in barns where contamination of fresh produce by birds is a possibility. Plastic strips can be hung in doorways to discourage birds, while allowing easy access by growers.

Lethal

Laws that Protect Birds

All native birds are protected by the Migratory Bird Treaty Act (MBTA). It is illegal to harm or harass any native birds, including by damaging their nests and destroying their eggs without a permit. There are exceptions to the MBTA. You may kill the species listed below without a permit if they are causing serious damage to agricultural crops, to livestock feed, or to buildings. But before you do, each year you must attempt to use nonlethal methods first, and you must file an annual report with the US Fish and Wildlife Service (USFWS): Blackbirds (Brewer's, Red-winged and Yellow-headed), Cowbirds (Brown-headed, Bronzed and Shiny), Crows (American, Fish and Northwestern), Grackles (Boat-tailed, Common, Great-tailed. and Greater Antillean) and Black-billed Magpies. Farmers in certain regions of California can kill some other pest bird species when working with their county Agricultural Commissioner.

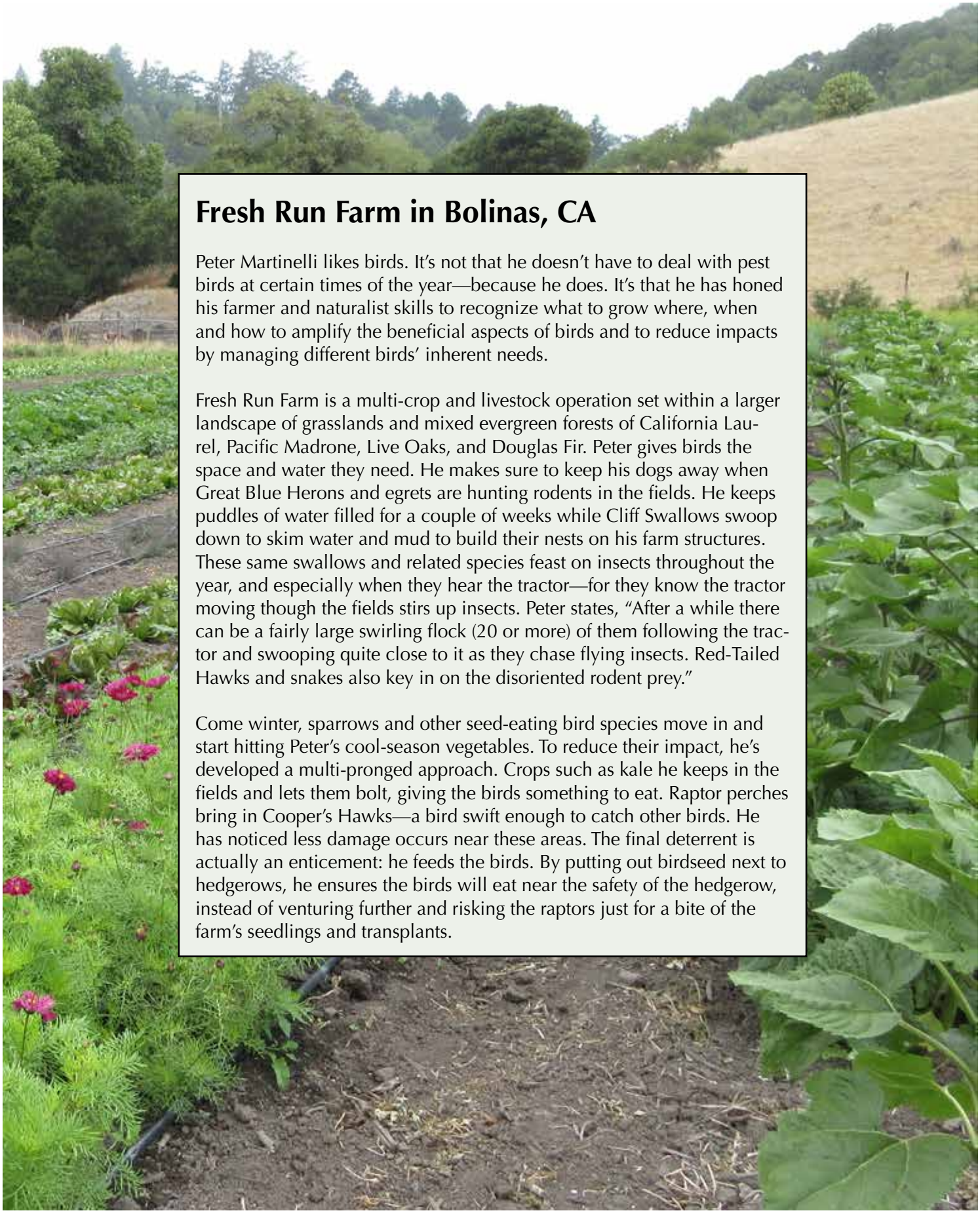
You are permitted to kill European Starlings and House Sparrows without a permit or a cause, according to the MBTA, because they are not native to the U.S. While at times the Starlings do help with pest control, they and the House Sparrows also outcompete native birds for cavity nesting sites and will destroy nests and the young of others. All of the above-mentioned birds may be protected under local ordinances, so be sure to consult with local wildlife authorities before taking steps. If you use lethal methods for the above-listed pest birds and native birds are killed, you are legally responsible.

While pest birds should be excluded from farm buildings, others, such as this Great Horned Owl that consumes large numbers of rabbits, mice, gophers, and ground squirrels, should be encouraged.

Shooting and Trapping

Using gunshots as a scaring technique to deter birds in crops can be effective (but see scaring techniques above). Shooting birds to kill them is ineffective; research has shown that one would need to kill greater than 90% of birds to be worthwhile. Shooting to kill also requires highly trained staff working outside of "normal" hours, it is potentially dangerous, and it can frighten and enrage neighbors. Birds protected by the Migratory Bird Treaty Act may also be illegally shot inadvertently.

Using live traps, target birds can be caught and either humanely killed (but see law section above) or released to another location. Bird trapping must follow federal regulations, including checking traps daily, providing shade for birds when temperatures are above 80° Fahrenheit, and supplying food and water. Non-target federally protected migratory birds must be immediately released unharmed or taken to a wildlife rehabilitator. Captures of non-target birds must be reported annually to USFWS. A survey of Michigan growers reported that trapping was the least effective bird deterrent.



Fresh Run Farm in Bolinas, CA

Peter Martinelli likes birds. It's not that he doesn't have to deal with pest birds at certain times of the year—because he does. It's that he has honed his farmer and naturalist skills to recognize what to grow where, when and how to amplify the beneficial aspects of birds and to reduce impacts by managing different birds' inherent needs.

Fresh Run Farm is a multi-crop and livestock operation set within a larger landscape of grasslands and mixed evergreen forests of California Laurel, Pacific Madrone, Live Oaks, and Douglas Fir. Peter gives birds the space and water they need. He makes sure to keep his dogs away when Great Blue Herons and egrets are hunting rodents in the fields. He keeps puddles of water filled for a couple of weeks while Cliff Swallows swoop down to skim water and mud to build their nests on his farm structures. These same swallows and related species feast on insects throughout the year, and especially when they hear the tractor—for they know the tractor moving though the fields stirs up insects. Peter states, "After a while there can be a fairly large swirling flock (20 or more) of them following the tractor and swooping quite close to it as they chase flying insects. Red-Tailed Hawks and snakes also key in on the disoriented rodent prey."

Come winter, sparrows and other seed-eating bird species move in and start hitting Peter's cool-season vegetables. To reduce their impact, he's developed a multi-pronged approach. Crops such as kale he keeps in the fields and lets them bolt, giving the birds something to eat. Raptor perches bring in Cooper's Hawks—a bird swift enough to catch other birds. He has noticed less damage occurs near these areas. The final deterrent is actually an enticement: he feeds the birds. By putting out birdseed next to hedgerows, he ensures the birds will eat near the safety of the hedgerow, instead of venturing further and risking the raptors just for a bite of the farm's seedlings and transplants.

What Farmers Can Do to Make Farms More Bird-Friendly and Resilient

1. Conserve and Install Bird-Friendly Habitat

Determine Which Birds Are Present

Most farmers are familiar with specific birds that cause damage to their crops, and many keep records of them.

Ideally, a farmer would note all the bird species present on their farm before installing bird-friendly habitat. Creating a baseline of knowledge, and continuing to monitor the bird numbers and species over time, can help to measure changes in bird presence and the effectiveness of the habitat.

The good news for those farmers who don't know their birds very well is that it is getting easier to identify them. A pair of binoculars and a bird identification guide are essential. Bird identification guides come in the form of books, cell phone apps, and websites.

Tools, resources and techniques for identifying the birds you have on your farm—or that you'd like to attract—are in the box on the next page.

Inventory Present Habitat

Before taking steps to support beneficial birds that can help control pests, it is useful to make an inventory of what habitat is already present and what landscape features could be used to the farm's advantage.

Sometimes the "unused areas" are actually vibrant habitats for birds and other wildlife, so look closely before removing what might be considered "weeds" or "non-productive woods." True weeds—those that compete with the crop or are invasive in natural areas—should be controlled and managed over time.

But other noncrop trees, shrubs, forbs and grasses, especially if they are native, should be conserved, since they are likely already supporting birds and other wildlife. Some habitat, such as wetlands and riparian streamsides, can be highly productive feeding sites for insectivorous birds. For example, Tree Swallows are healthier on farms adjacent to wetlands which provide a large percentage of highly nutritious aquatic insects in the birds' diet.

Leaving snags (standing dead and dying trees) can offer many birds perching and roosting sites, and for those that nest in cavities, a place to raise their young. As snags decay and lose limbs, many large cavities are created for shelter and nesting of birds. Woodpeckers also create cavities that other birds use. Snags can offer food, too. As the tree dies, wood-boring beetles move in and woodpeckers follow to consume them. Trees likely to become snags in the near future often: a) are oozing sap, b) have damaged or dead main limbs, c) are growing fungi on the bark, or d) have woodpecker holes. Orchard growers might consider leaving a few of their old orchard trees in place when converting their orchard to a younger stand or a new crop. Older, more furrowed trees have been shown to attract woodpeckers and to increase the killing of Codling Moths by birds.

Survey Where to Plant Habitat

The unfarmed areas or the places that continually take more effort than they are worth to farm are excellent candidate sites for bird habitat. Those odd-shaped pieces of

Conserving snags supports birds looking for perches, shelter, nesting sites and food.

Identifying Birds You Have or Want to Attract

Cornell Lab of Ornithology has three valuable, user-friendly tools that can help you identify birds on your farm. These can also aid you in deciding which birds you'd like to attract prior to installing vegetative habitat or a bird structure. An alternate technique for learning and identifying birds uses a "Sit Spot" (see below).

Merlin Cell Phone Bird App

The Merlin Bird ID App for cell phones is free and straightforward to use. It asks simple questions about a bird you are trying to identify—when and where you saw the bird, what it looks like, its behavior, etc.. Merlin then comes up with a list of possible matches for birds in North America. A photo of the bird in question can also be uploaded onto Merlin's Photo ID part of the tool and it will offer a list of possible matches. Merlin is drawing information from eBird's online database (see below) http://merlin.allaboutbirds.org/

eBird

eBird is an online database of bird sightings from birders who have posted them near you and in other areas. By going to this website and using their Explore Species Maps, you'll discover if the birds you want to attract with habitat are common, infrequent, what time of year they are seen, or if they occur in your area. https://ebird.org/home

All About Birds Website

The All About Birds website provides a search feature to learn more about birds in your area. It gives an overview of habitat, food, and nesting requirements; behavior; conservation status; ID information; maps; and songs of specific birds. https://www.allaboutbirds.org/

Sit Spot

Another way to learn about birds is to find a "Sit Spot," as author Jon Young calls it, where you quietly observe the birds daily, weekly, or for however much time you have. Pick a location where you can see birds and possibly other wildlife coming and going, such as near a pond, or anywhere on the farm that is quiet. Just as birds habituate to scarecrows, they will get used to your presence when they see you are not a threat. The beauty of the Sit Spot is getting to see the birds up close and to hear them communicate with each other—a memorable way to learn. Birds communicate with companion calls (often constantly communicating with each other: Are you there? Yes I am. Are you there?); with songs, territorial aggression, and begging (during nesting season); and with alarms when predators are present. Keeping records of what is seen and heard is helpful.

As with anything, it takes time, patience and practice to develop skills, but farmers are good observers and learners. While many farmers don't feel that they have the time to take away from their pressing daily tasks, this simple practice will help them learn about an important level of biological activity that is occurring on the farm.

Merlin Cell Phone Bird App helps identify this little brown bird (with insect) as a Pacific-slope Flycatcher by asking when and where you saw the bird, what it looks like, and what it was doing.

Additional Assistance

It is not necessary to be able to list all the birds on your farm in order to support them. Other people may be available to help. In California, and less so nationwide, NRCS has partner biologists familiar with bird identification. Meeting bird experts while participating in bird club field trips is a good way to find help, and to learn along the way about how to identify birds you see. Just because you don't know every bird on your farm doesn't mean you can't learn about and benefit from them.

land where the tractor can't work, or which are too steep, rocky or wet to farm efficiently, usually end up sporting weeds when they could be covered in beneficial bird habitat. Farm edges along fence lines, near roads, and adjacent to waterways are also potential bird habitat sites.

Birds are known to consume pests 650 feet or more from a field's margin, though they usually focus their foraging efforts between 65-165 feet from the edge. Since many birds will not go far from protective cover, breaking up larger fields into smaller ones with a patchwork design of hedgerows, windbreaks, field borders, and riparian areas may make it easier for birds to find the pest insects.

Taking notice of the lay of the land—where it sits in the watershed and how water and wildlife move through it—can help inform locations for habitat installation. Birds and other wildlife are attracted to water. Farmers can provide high quality resources for insect-eating birds by widening ditches and canals; using less steep banks and planting them with vegetation to provide habitat for birds; and protecting and augmenting riparian habitat along creeks and ponds (see Chamberlain Farms story). For those farms without water flowing through, habitat connections between hedgerows and other native patches and along farm edges can be made, linking them to wilder areas.

Plant Diverse Habitat and Make It Native

Try to create farm habitat that closely resembles the natural areas where the bird you are interested in attracting has evolved. Trees and shrubs that give structural complexity to field margins such as hedgerows, windbreaks, and riparian forests are important to bird species that use forest interiors or forests that abut other habitat such as grasslands. The size and area of the habitat is also important: woodland birds prefer woody vegetation that is taller, wider, and has more volume. Grassland birds, on the other hand, prefer margins composed of grasses and forbs and will avoid areas with shrubs and trees.

Smaller fields with more edge habitat, such as this hedgerow, will support more birds especially when those farms are surrounded by monocultures.

Any one kind of habitat may provide only part of what birds need, and so should be considered in relation to other nearby habitat that could meet the rest of their requirements. Therefore, isolated farm habitat patches such as windbreaks are most valuable when combined and/or connected with other features such as pollinator strips, riparian areas, grasslands, wetlands, and woodlands.

Native plants should be used when installing habitat, since they often support birds and beneficial insects more than do nonnative plants. Nonnative plants do provide structure and sometimes food for birds, however, and are better than no vegetation at all. As nonnatives die from previous plantings around fields and farmsteads, they should be replaced with natives. Audubon's Native Plant online database (https://.audubon.org/native-plants) makes it easy to determine which plants to grow in a given region. After entering a zip code, a suggested plant list for that area is provided, which can be filtered by the types of plant resources (nectar, butterflies, caterpillars, fruit, nuts, and seeds) and bird families you'd like to attract. Make sure to include caterpillars so that you provide birds with the best insect food known for their nestlings. The database also lists places to buy these plants in your region and online.

Provide Water Sources

Most birds need a dependable water supply for drinking and bathing, and some birds use it for building mud nests. Bathing is critical; it keeps their feathers in good shape, removes parasites and ensures good body insulation in cold weather. When farms do not have natural year-round water sources, water can be easily provided by adding extra drippers to a drip system and placing a pan underneath to collect water that birds and other wildlife can use. A bigger project would be installing a pond and planting habitat around it. Ponds should be built with the help of experts so that they hold water well and meet all regulations. Besides supporting birds, growers have found that having water sources in and near their orchards will discourage ripe fruit injury and damage to drip systems, especially in dry years.

A pair of Barn Owls and their nestilings ate about 200 pounds of rodents per year in California.

Manage Farm Fields

Although more birds use fields near habitat edges, some birds use the fields themselves, especially when there are more permanent crop covers such as orchards, winter grain fields and pastures. Conservation tillage with fewer tractor passes and tilling will leave more residue on the soil surface, providing more food (insects and waste grain) and cover for birds than conventional tillage. Non-herbicide no-till practices, where the crop is planted directly into existing plant residues, also supports more birds (see Paicines Ranch story).

Using fewer herbicides and chemical fertilizers will conserve more birds on farmland. Organic farming can as well, largely because it offers greater food and cover resources, including a diversity of plants and insects, and more mixed farming and habitat.

2. Put Up Nesting and Perching Structures

Make Plans Early for Nest Boxes and Nest Platforms

Months before the nesting season, all nest boxes and platforms (frame or shelf-like design) should be in place so that birds scouting out a nest site will find them when needed, and not be frightened away as you install the structures. Nesting season generally stretches from February to August, but the actual nesting period for any bird species is usually 3-4 months within that bigger range. The length of the season depends in part on whether the birds will attempt more than one clutch, which could be due to abundant food sources or earlier nesting failure because of predators. Table 1 shows which beneficial birds can be supported with nesting boxes or structures.

Barn Owl Nest Boxes

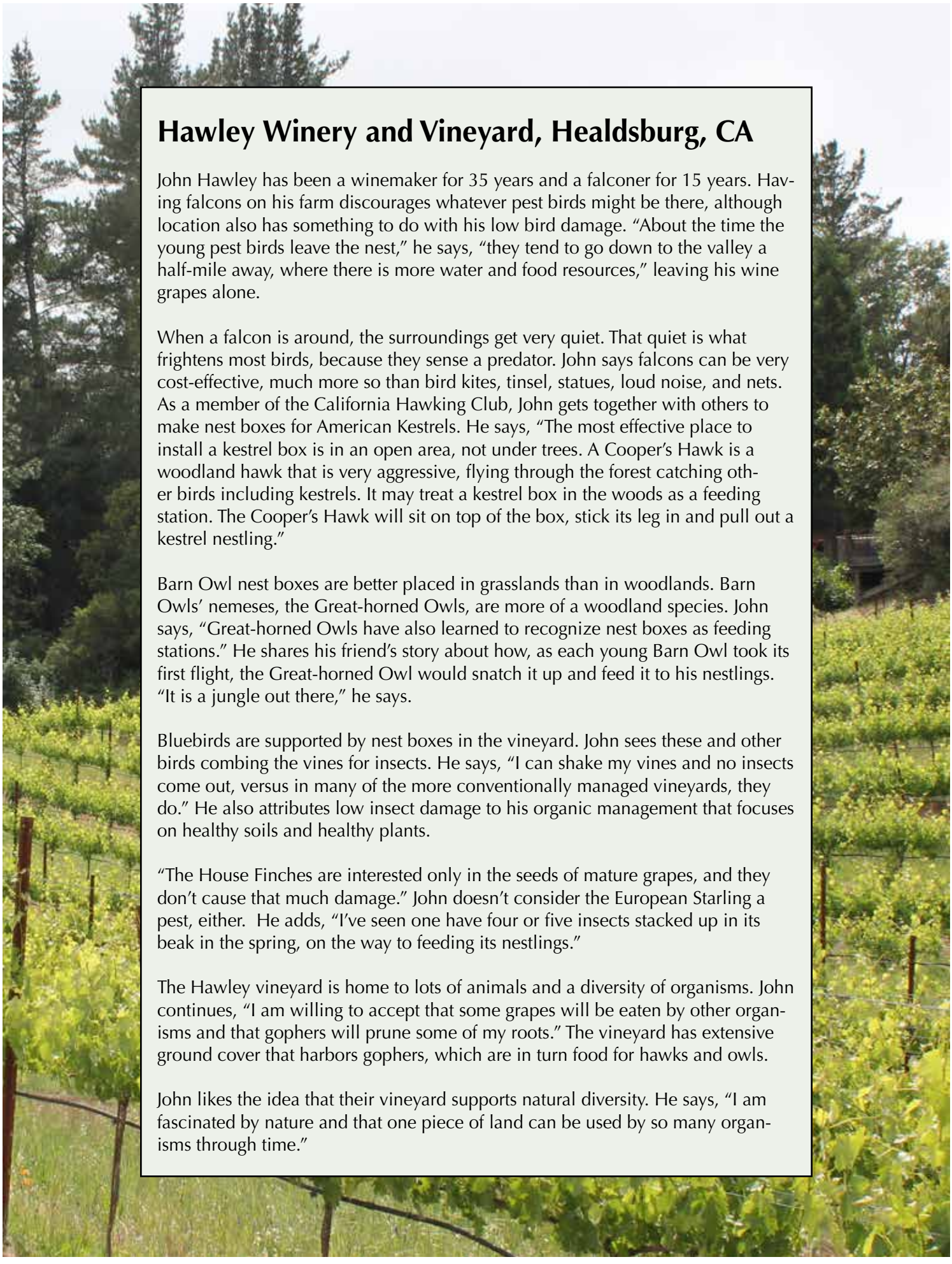
If you've never put up a nest box, and rodents are an issue on the farm, consider installing your first one for Barn Owls. Farmers have been installing owl nest boxes for dozens of years, and research shows they can be effective if rodent populations are not extreme. Barn Owls live in many parts of the country, and their habit of spitting up pellets composed of their prey's fur and bones beneath the nest box shows how beneficial they can be.

Use Nesting Structures Tailored to the Birds You Want

Whether building or purchasing a nesting structure, each one should be tailored to the bird you are trying to attract. The size of the entrance hole of the nest box is of utmost importance. Sized correctly, the hole will only admit the bird you want and others of its size or smaller. Tree and Violet-Green Swallows and Western and Eastern Bluebirds use the same size hole, and for that reason will compete for nest boxes. Having different types of insect-eating birds on the farm is always a plus, because they consume different kinds of prey (see Tres Sabores Vineyard story). If the nest boxes are incorrectly sized, pest birds such as European Starlings may move in, kill the nestlings, and raise their own young there instead. Over time, other birds and squirrels may try to increase the entrance hole size and take over the box, so using a "hole guard" may be necessary.

Construction plans that describe the building material to use, how to build the structure and how to place it

Using a "hole guard" prevents other birds and squirrels from enlarging the hole and displacing the desired birds.



Hawley Winery and Vineyard, Healdsburg, CA

John Hawley has been a winemaker for 35 years and a falconer for 15 years. Having falcons on his farm discourages whatever pest birds might be there, although location also has something to do with his low bird damage. “About the time the young pest birds leave the nest,” he says, “they tend to go down to the valley a half-mile away, where there is more water and food resources,” leaving his wine grapes alone.

When a falcon is around, the surroundings get very quiet. That quiet is what frightens most birds, because they sense a predator. John says falcons can be very cost-effective, much more so than bird kites, tinsel, statues, loud noise, and nets. As a member of the California Hawking Club, John gets together with others to make nest boxes for American Kestrels. He says, “The most effective place to install a kestrel box is in an open area, not under trees. A Cooper’s Hawk is a woodland hawk that is very aggressive, flying through the forest catching other birds including kestrels. It may treat a kestrel box in the woods as a feeding station. The Cooper’s Hawk will sit on top of the box, stick its leg in and pull out a kestrel nestling.”

Barn Owl nest boxes are better placed in grasslands than in woodlands. Barn Owls’ nemeses, the Great-horned Owls, are more of a woodland species. John says, “Great-horned Owls have also learned to recognize nest boxes as feeding stations.” He shares his friend’s story about how, as each young Barn Owl took its first flight, the Great-horned Owl would snatch it up and feed it to his nestlings. “It is a jungle out there,” he says.

Bluebirds are supported by nest boxes in the vineyard. John sees these and other birds combing the vines for insects. He says, “I can shake my vines and no insects come out, versus in many of the more conventionally managed vineyards, they do.” He also attributes low insect damage to his organic management that focuses on healthy soils and healthy plants.

“The House Finches are interested only in the seeds of mature grapes, and they don’t cause that much damage.” John doesn’t consider the European Starling a pest, either. He adds, “I’ve seen one have four or five insects stacked up in its beak in the spring, on the way to feeding its nestlings.”

The Hawley vineyard is home to lots of animals and a diversity of organisms. John continues, “I am willing to accept that some grapes will be eaten by other organisms and that gophers will prune some of my roots.” The vineyard has extensive ground cover that harbors gophers, which are in turn food for hawks and owls.

John likes the idea that their vineyard supports natural diversity. He says, “I am fascinated by nature and that one piece of land can be used by so many organisms through time.”

correctly—such as the correct height, cardinal direction, and spacing between other nest boxes—can be found on Cornell Lab of Ornithology's NestWatch webpages. https://nestwatch.org/learn/all-about-birdhouses/ Also consider what type of habitat the nest boxes are placed in, because as John Hawley describes (see Hawley Winery story), the wrong type can mean nest failure.

Provide Predator Protection

Nest structures can be easy targets for predators such as cats, rats, raccoons, snakes, and squirrels. If cats live on the farm, avoid placing the structures where cats spend much of their time. Also, mount structures high on poles and away from trees and fences to make it hard for cats and raccoons to jump to the top of the structure, reach in and grab eggs or nestlings to eat. Predator guards, such as conical metal collars on the poles underneath the boxes, can act as barriers to keep animals from climbing up to reach the nest structures.

Monitor Nest Structures

In conjunction with providing protection against invading species, the nest structures should be monitored. If undesirable species are found, stronger actions should be taken to discourage them. Nest structures should also be cleaned out yearly before each nesting season.

Raptor Perches

Perches are attractive to raptors because they allow them to spend less energy in one spot as they hone in on their prey, compared to the energy required for hunting on the wing. Unlike nest boxes, raptor perches can be erected throughout the year, although they may be especially beneficial in the winter and early spring when rodent populations start to build.

Perches are used by raptors such as this Golden Eagle, and are effective when placed towards the tops of hills and in open habitat.

Raptor perches can help reduce pests. In one study on rodent control, costs for perches were half as much as rodenticides. In another study on pest bird control, perches reduced crop damage by 50%. According to NRCS, perches should be spaced at least 50 yards apart. If a farm has a natural area such as a grassland or wetland, or is adjacent to one, the perch should be placed at least 300 feet away so it does not affect the habitat's value for some beneficial species that may live there. Perches are used most often if they are placed near the tops of hills rather than along the bottom of hills, and if they are further from trees rather than near them.

Grow Sunflower and Sorghum Perches

Planting living perches such as sunflowers and sorghum can support birds as they consume pest insects. Taller rows of plants interspersed in the farm can draw birds into the interior, giving them a place to hunt from while hawking insects instead of staying on the sidelines. In studies using living perches in mixed crop fields and in dried bean crops, the birds caused no damage. Besides supporting beneficial birds, living perches may increase natural enemy insect abundance, act as a trap crop for pest larvae, and provide harvestable flowers for market.

3. Obtain Conservation Assistance

Environmental Quality Incentive Program (EQIP)

Growers looking for help with installing practices to support birds should consider working with the USDA Natural Resources Conservation Service (NRCS). Both free technical assistance and financial support are available. Applications for cost-share funds that sufficiently address the degraded habitat elements are most likely to compete well for available funding. Table 2 shows some of the NRCS practices in their Environmental Quality Incentive Program (EQIP) that benefit birds, and also indicates how these practices make the farm more resilient as the climate changes. NRCS staff in your area can visit with you to help develop one or more of these plans and identify opportunities to support birds and conserve natural resources.

Sunflowers offer insect-eating birds perching sites in the interior of the farm. These plants also support pollinators and natural enemy insects.

Multiple Benefits

Habitat can benefit other parts of the farm, besides providing for the birds themselves. Natural enemy insects, pollinators, reptiles, amphibians, and wild mammals can build their populations with added food and cover from native habitat. Other creatures such as bats, which are in decline, may find places to roost when trees are present. This habitat brings beneficial wildlife closer to crops so they can better offer their pollination and pest control services. The habitat may also serve as wildlife movement corridors for animals shifting their ranges to cooler or warmer areas.

In some places, where more intense rains from climate change are causing increased soil erosion and flooding, bird habitat can reduce those impacts. This habitat may cover and protect fertile soil and riverbanks from wind and water erosion, reducing the pollutants that enter surface waters.

In other areas, less precipitation is impacting both farm production and the beneficial organisms that rely on natural habitat. Ponds can help store what rain does come (see Citrona Farm story) so it can later be used in drought.

Woody shrubs and trees can store more carbon per area than grasslands. For example, on one farm, woody vegetation (hedgerow and riparian habitat) stored 18% of the farm's carbon, despite occupying only 6% of the total area. Riparian zones can also capture and assimilate excess nitrogen in runoff before it pollutes a stream or is released into the atmosphere.

Conservation Stewardship Program

NRCS also provides assistance through their Conservation Stewardship Program (CSP). In order to enroll in CSP, growers must have already implemented at least one conservation practice, such as a hedgerow, on their land. CSP offers enhancements to those practices. For a hedgerow, that could mean augmenting it with native plants to better support birds or pollinators, or making it denser to better intercept dust or pesticide drift. CSP may also enhance collection of rainfall and management of moist soil vegetation on cropland edges to increase birds' food sources, or enhance practices to better serve as wildlife movement corridors.

Other Assistance

USDA's Farm Services Agency (FSA) offers financial assistance to organic farmers to establish strips of habitat along field edges. They offer to make annual payments to all farmers who remove environmentally sensitive land from production and plant species that will improve environmental health and quality. Other assistance may be sought from Conservation Districts located in most counties in the U.S. Additionally, California's Department of Food and Agriculture offers funds through its Climate Smart Agriculture Program, which supports many of the same conservation practices listed in Table 2.

Farm ponds can support a diversity of birds and other wildlife. They can also provide water during a drought and for fire protection.

Table 2. Selected NRCS Conservation Practices that Support Birds and Provide Farm Resilience

USDA NRCS Conservation Practices	Supports Birds	Provides Resilience to Weather Extremes				
EQIP (Environmental Quality Incentive Program)	Provides Habitat for Birds (food, cover, shelter, roosting and nesting sites and/or water)	Supports Other Beneficial Organisms with habitat	Stores Carbon and Excess Nitrogen in woody biomass and/or in soil	Protects Soil from erosion caused by intense storms	Reduces Flooding caused by intense storms and/or Drought & Fire Impacts caused by low rainfall	Protects Crops from intense storms and/or increased pest pressure
Alley Cropping	x	x	x	x		x
Brush Management	x	x		x	x	x
Conservation Cover	x	x	x	x		x
Conservation Tillage	x	x	x	x	x	x
Field Borders	x	x	x	x		x
Hedgerow Planting	x	x	x	x		x
Integrated Pest Management	Reduces risk of pesticides	Reduces risk of pesticides				x
Multi-story Cropping	x	x	x	x		x
Pond	x	x			x	x
Prescribed Grazing	x	x	x	x	x	x
Riparian Herbaceous Cover	x	x	x	x	x	x
Riparian Forest Buffer	x	x	x	x	x	x
Silvopasture	x	x	x	x	x	x
Structures (brush piles)	x	x				x
Structures (Burrowing Owl burrows)	x					x
Structures (escape ramps)	x	x				x
Structures (fence markers)	x					x
Structures (nest boxes)	x					x
Structures (perches)	x					x
Structures (snag creation)	x	x				x
Tree and Shrub Establishment	x	x	x	x		x
Wetland Restoration	x	x	x		x	x
Wildlife Habitat Planting	x	x	x	x		x
Windbreak	x	x	x	x		x
Upland Wildlife Habitat	x	x	x	x		x

4. Be Aware of Food Safety Issues

FDA's Produce Rules

The Food and Drug Administration's (FDA) Produce Rules are written for "freshly eaten" crops—not crops cooked or made into alcohol. FDA does not require farms to exclude birds or other wildlife, or to destroy their habitat around farm borders or drainages. They state that animals in and of themselves are not a significant food safety risk. Instead, they require farmers to monitor freshly eaten crops during the growing season and at harvest for significant evidence of potential contamination by wild birds and other animals. Observation of significant numbers of animals, significant amounts of animal feces or significant crop destruction determines how much of the crop can or can't be harvested.

Birds Exposed to Contamination May Pick It Up

Studies have thus far indicated that the occurrence of human pathogens in wild birds is low. When the birds have tested positive, they are usually the species associated with livestock operations or other areas with high levels of pathogens. European Starlings associated with dairies or cattle feedlots (and probably feeding on spilled grain) were found with low levels of pathogenic *E. coli* and *Salmonella*. Brown-headed Cowbirds and American Crows had low levels of pathogenic *E. coli*, probably because the former eat seeds and insects from cattle feces, and the latter eat garbage and carrion. Rock Pigeons near a dairy farm were found with low levels of *Salmonella*. Many bird species not mentioned here have tested negative for these pathogens. While generally birds and other wildlife have a low relative prevalence of carrying human pathogens, localized conditions may create situations that cause concern.

Reduce Contamination Risk

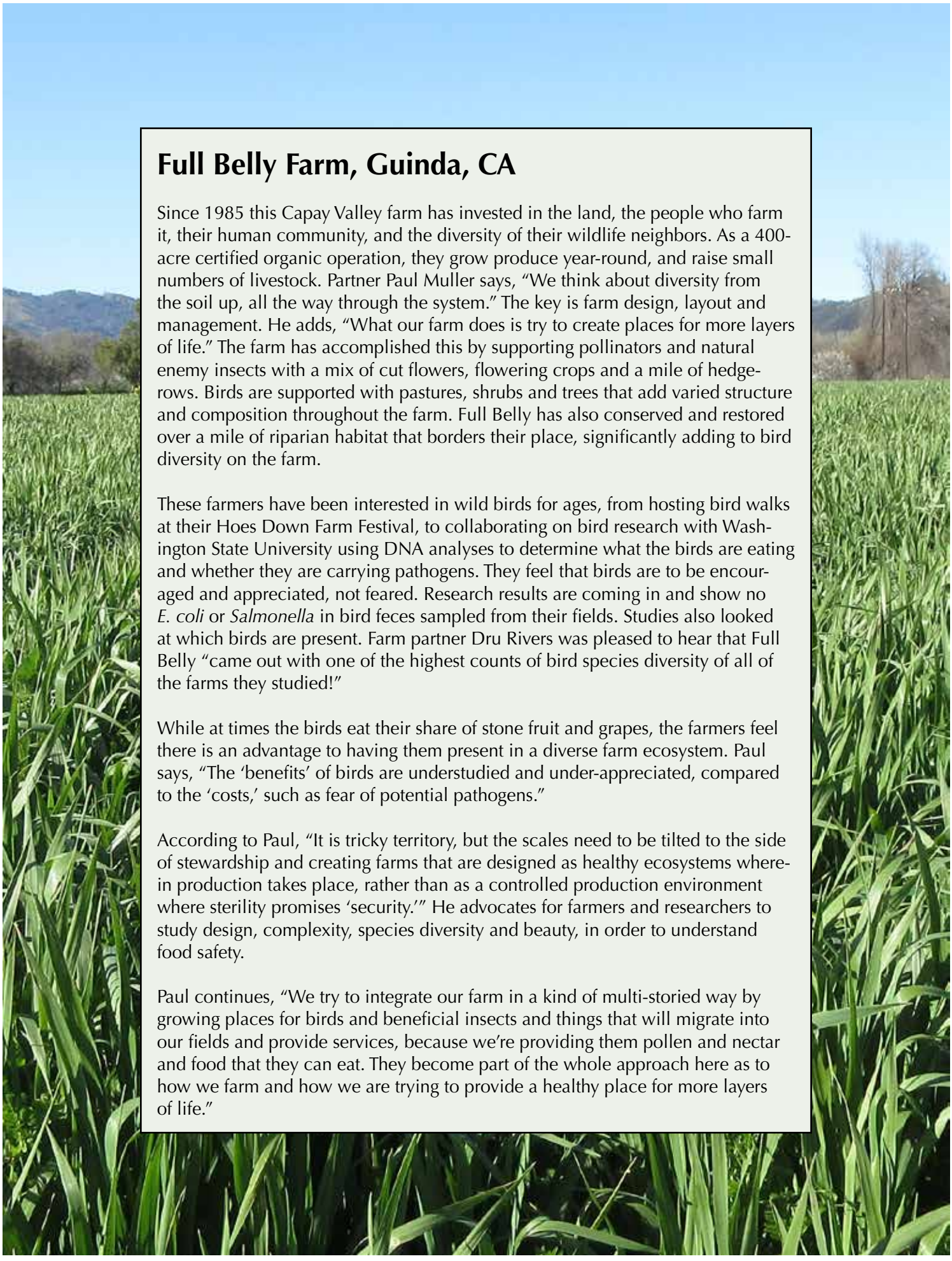
To lessen the risk of contamination, freshly eaten crops should not be planted or harvested under telephone wires or trees where large congregations of birds roost. Neither should these crops be irrigated with water from ponds where large numbers of birds are roosting on overhanging trees. Nest structures and perches should be installed near but not over freshly eaten crops. If livestock are present, access to their food by birds should be restricted.

Habitat May Not Increase Risk

In a study of farms with and without hedgerows, rodents were found to be throughout the fields and were not specifically associated with the habitat. Additionally, hedgerows did not cause a noticeable increase in pathogen prevalence in the rodents. Less than 1% of rodents tested positive for *Salmonella* in walnuts and 0% in tomatoes; 0% of rodents tested positive for *E. coli* O157 in both tomatoes and walnuts. A common practice thought to reduce rodents in fields with hedgerows is to trim off the lower branches, but doing this may not be necessary in many cases, and it decreases songbird habitat.

In a study reviewing over 200,000 produce samples tested for pathogens collected for seven years after the 2006 spinach contamination on farms with and without habitat—it was reported that removal of field-edge habitat may increase pathogen levels. Another study suggests that non-crop vegetation clearing and indiscriminate poison baiting may decrease the diversity of rodent species and increase the overall pathogen load of remaining rodents. The relationships between farm management, pathogens, wild animals, and native habitat is complex. Research is continuing on the occurrence of wild birds carrying pathogens, ways to discourage birds from contaminating crops, and impacts of habitat and habitat removal on pathogen prevalence in crops. The FDA wrote in its Preamble to the Produce Rule: "We continue to encourage the co-management of food safety, conservation, and environmental protection," as does Full Belly Farm (see their story).

Take care not to plant freshly eaten crops under wires or trees where large groups of birds congregate.



Full Belly Farm, Guinda, CA

Since 1985 this Capay Valley farm has invested in the land, the people who farm it, their human community, and the diversity of their wildlife neighbors. As a 400-acre certified organic operation, they grow produce year-round, and raise small numbers of livestock. Partner Paul Muller says, "We think about diversity from the soil up, all the way through the system." The key is farm design, layout and management. He adds, "What our farm does is try to create places for more layers of life." The farm has accomplished this by supporting pollinators and natural enemy insects with a mix of cut flowers, flowering crops and a mile of hedgerows. Birds are supported with pastures, shrubs and trees that add varied structure and composition throughout the farm. Full Belly has also conserved and restored over a mile of riparian habitat that borders their place, significantly adding to bird diversity on the farm.

These farmers have been interested in wild birds for ages, from hosting bird walks at their Hoes Down Farm Festival, to collaborating on bird research with Washington State University using DNA analyses to determine what the birds are eating and whether they are carrying pathogens. They feel that birds are to be encouraged and appreciated, not feared. Research results are coming in and show no *E. coli* or *Salmonella* in bird feces sampled from their fields. Studies also looked at which birds are present. Farm partner Dru Rivers was pleased to hear that Full Belly "came out with one of the highest counts of bird species diversity of all of the farms they studied!"

While at times the birds eat their share of stone fruit and grapes, the farmers feel there is an advantage to having them present in a diverse farm ecosystem. Paul says, "The 'benefits' of birds are understudied and under-appreciated, compared to the 'costs,' such as fear of potential pathogens."

According to Paul, "It is tricky territory, but the scales need to be tilted to the side of stewardship and creating farms that are designed as healthy ecosystems wherein production takes place, rather than as a controlled production environment where sterility promises 'security.'" He advocates for farmers and researchers to study design, complexity, species diversity and beauty, in order to understand food safety.

Paul continues, "We try to integrate our farm in a kind of multi-storied way by growing places for birds and beneficial insects and things that will migrate into our fields and provide services, because we're providing them pollen and nectar and food that they can eat. They become part of the whole approach here as to how we farm and how we are trying to provide a healthy place for more layers of life."

5. Take Care When Using Pesticides

While pesticides can be an effective solutions to the reduction of crop pests, they have significant risks to beneficial birds. Cholinesterase inhibitors, which are active ingredients of organophosphate and carbamate pesticides, affect avian thermoregulation (maintenance of core temperature), reproduction, and food consumption. The neonicotinoid insecticide imidacloprid was linked to bird population declines when high levels were found in waterways. Imidacloprid and chlorpyrifos impair birds' ability to orient correctly when migrating. The use of first- and second-generation anticoagulant rodenticides (SGARs) often have side effects of poisoning predatory wildlife. Even with new restrictions on SGARs in California that limit their use near structures, raptors are exposed through consumption of rodents that can travel up to 300 feet from their burrows to seek food and water.

Do you plan to use pesticides on your farm?

Review the information below before you apply any pesticides, whether organic or not, to ensure you are protecting birds, other beneficial animals and their habitat. Non-pesticidal practices are associated with far less risk than using pesticides and can work better when integrated with beneficial avian pest control.

For example, growing the appropriate crops for the region and providing what they need for optimum health will help prevent pest attacks. When controlling for many pests, use floating row covers, pheromone mating disruption, bacterial sprays, beneficial insect releases, sanitation, and habitat installation that supports natural enemy insects and birds. For soil pests, treatments may include a soil bacterium or beneficial nematodes. For weeds, mow well before or after nesting. For pest birds, see management section above.

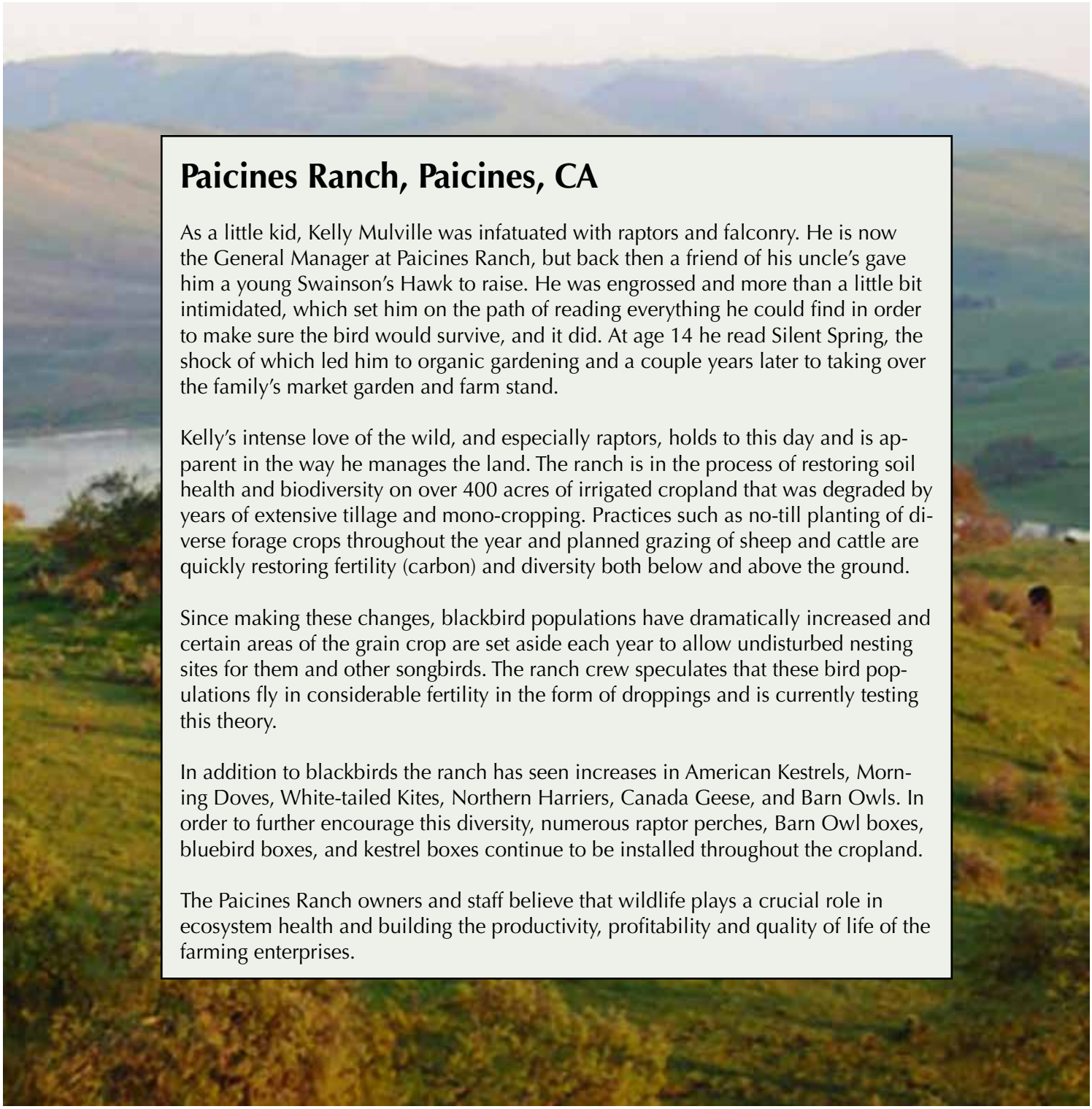
Pest Management Checklists

IPM Plan

Before any spray is applied, a strong IPM plan should be in place that includes:
___**Accurate Identification**. Correctly identify any pest insects. Know the physical features of the pest, what plants it prefers, its life history, and what the damage it causes looks like.
___**Prevention**. Knowing what pests are problematic for your crops, you can implement practices that will help prevent the populations from spiraling out of control.
___**Pest Monitoring**. Periodically scout the fields to monitor their population. Use monitoring traps, when appropriate. Recognize that natural enemy allies need some of the pests for food.
___**Thresholds for Pests and Your Crops**. Determine what level of pest invasion can be tolerated before action should be taken. A sighting of one or two pests doesn't necessarily indicate that a pesticide must be used. Plants can tolerate some level of pest pressure. It is rarely necessary or optimal to eliminate all pests. If all pests are removed, it may cause a die-off of the natural enemy insects, allowing other insects to become pests. Consider whether conditions would support the rapid spread of the pest.

Protecting Birds When Using Pesticides

If you determine pesticides are needed, use the checklist below to ensure that you are protecting beneficial birds and other natural enemies that provide pest management services:
___Provide buffer of at least 30 feet between pesticide application and habitat.
___Prioritize the use of pesticides with the lowest toxicity to beneficial birds and natural enemy insects.
___Only apply pesticides when the threshold for pest abundance is reached.
___Treat only the areas where the pest has been found.
___Apply during the most susceptible phase of the pest's life cycle.
___Do not apply insecticides during bloom periods of crops.
___Spray only on calm, non-windy days, or even better, at night.
___Never allow wash water from cleaned out tanks to enter waterways, or to pond on the ground where birds may drink and bathe in it.



Paicines Ranch, Paicines, CA

As a little kid, Kelly Mulville was infatuated with raptors and falconry. He is now the General Manager at Paicines Ranch, but back then a friend of his uncle's gave him a young Swainson's Hawk to raise. He was engrossed and more than a little bit intimidated, which set him on the path of reading everything he could find in order to make sure the bird would survive, and it did. At age 14 he read Silent Spring, the shock of which led him to organic gardening and a couple years later to taking over the family's market garden and farm stand.

Kelly's intense love of the wild, and especially raptors, holds to this day and is apparent in the way he manages the land. The ranch is in the process of restoring soil health and biodiversity on over 400 acres of irrigated cropland that was degraded by years of extensive tillage and mono-cropping. Practices such as no-till planting of diverse forage crops throughout the year and planned grazing of sheep and cattle are quickly restoring fertility (carbon) and diversity both below and above the ground.

Since making these changes, blackbird populations have dramatically increased and certain areas of the grain crop are set aside each year to allow undisturbed nesting sites for them and other songbirds. The ranch crew speculates that these bird populations fly in considerable fertility in the form of droppings and is currently testing this theory.

In addition to blackbirds the ranch has seen increases in American Kestrels, Morning Doves, White-tailed Kites, Northern Harriers, Canada Geese, and Barn Owls. In order to further encourage this diversity, numerous raptor perches, Barn Owl boxes, bluebird boxes, and kestrel boxes continue to be installed throughout the cropland.

The Paicines Ranch owners and staff believe that wildlife plays a crucial role in ecosystem health and building the productivity, profitability and quality of life of the farming enterprises.

Bird Benefits Beyond Pest Control

Besides helping with insect and rodent pest control, birds carry out other needed functions on the farm and in our landscapes. Some consume seeds, such as digesting weedy thistle seeds in pastures. Others hoard acorns of native oaks, spreading them across rangeland. Waterfowl reduce weeds in rice and foster nutrient cycling, which speeds up residue decomposition in winter-flooded fields. Birds also pollinate flowers in crops such as feijoas and loquats, and in non-crop vegetation on the farm and in the wild. Scavengers eat dead organisms, reducing pathogens in the environment.

Historic and Current Knowledge of the Role Birds Play in Agriculture

Pioneers, Economic Ornithology and Bird Stomachs

Back when stagecoaches and trains delivered the mail, they were also carrying dead wild birds shot by farmers for research. Anecdotal stories about birds consuming crops and pests were mounting, and a 42-year-old entomologist named C.V. Riley took the lead in determining what birds ate and whether they were friends or foes. Farmers and others were instructed to kill birds, pickle their gizzards and stomachs in alcohol, state the farm's principal crops, and post the packages in the mail.

All of this was made possible by the newly formed Division of Economic Ornithology, which began in 1885 as part of the USDA. Congress appropriated $5,000 at the urging of the American Ornithologists' Union because birds were being killed in huge numbers without an understanding of their economic benefits. Dr. C. Hart Merriam ran this Division, focusing on bird migrations, while C.V. Riley—sometimes known as the Father of Biological Control —focused on birds' food habits. The Division of Economic Ornithology was especially interested in the stomachs of hawks, owls, crows, jays, blackbirds, cowbirds, doves, woodpeckers, quail, sparrows, bobolinks, and kingbirds because they were thought to affect agricultural interests. Research soared on this topic through the 1920s, with over 700 papers published. See Tables 3 and 4 for early analyses of pest insects and weeds that birds ate.

During this time and over the next 50 years, another luminary ornithologist, S.A. Forbush, examined what thousands of birds ate, and he wrote about the "complexity of the food relations existing between birds and other organisms." He explained that hawks and owls prey on crows and robins, keeping them from becoming too numerous, which would then deplete the number of predacious beetles. Forbush was interested in all food that birds ate, including weed seeds (see Table 3).

A Silent Spring Before Bird Studies Resume

With the advent of organochlorines like DDT in the 1940s, the study of both Biological Control (using one organism to control another) and Ecology (the relation between organisms and the environment) took a back seat, causing USDA's Division of Economic Ornithology to fade away. When Rachel Carson published Silent Spring in 1962, she cautioned the world about the unbridled use of DDT—not just because it is acutely toxic and kills birds outright, but also because it persists and accumulates in the food web. She reminded us that without insects, we wouldn't have birds or their beautiful songs. While Carson's book was a wake-up call, it also showed a path forward. She pointed out nature-based solutions, observing that "Woodpeckers … are important in the control of the codling moth in apple orchards. Chickadees and other winter-resident birds can protect orchards against the cankerworm." Her book built the case for a safer, more song-filled world.

Carson was referring to some of the few beneficial bird studies that had been conducted since the widespread use of DDT. It was not until the latter part of the 20th century that research started to regain traction and be more sophisticated than simply examining bird stomachs.

Rachael Carson's influential Silent Spring revealed how pesticides had the potential to decimate bird populations and thus eliminate beautiful songs of birds like this Yellow Throat, which can live in a farm's riparian vegetation.

Numbers and Extent of Studies Increase Dramatically

Observations of bird predation activity were made early on and continue to this day. In the past several decades, there has been an increase in researchers using bird exclosures and either actual crop pests or live or plastic sentinel prey to measure the extent and effects of pest reduction by birds. Measures of pest abundance, reductions in crop damage, yield and net profit are now frequently compared between plots from which birds are excluded to those where birds have full access. Studies also may track whether the same or different bird species cause crop damage.

Other modern research tools also allow us to dig deeper into what birds are eating and how that affects pest control without having to kill birds to collect samples. New genetic techniques offer finer taxonomic resolution and require fewer samples that can be analyzed more cheaply and quickly, permitting us to better understand which pests the birds are consuming and whether they are eating natural enemy insects or carrying pathogens. For example, in wine grapes researchers determined that plant-eating insects were present in 56% of bird fecal samples collected, and natural enemy insects were 3%. Additionally, advanced modeling techniques provide researchers with the tools to predict future outcomes based on past research. In one Barn Owl study, for example, extrapolations were made from the nesting behavior and diet of a pair of owls to predict the yearly number of rodents they and their offspring would eat and how well Barn Owls could control the pests, given the number of nest boxes in an area.

Examining Pest Reduction Effects

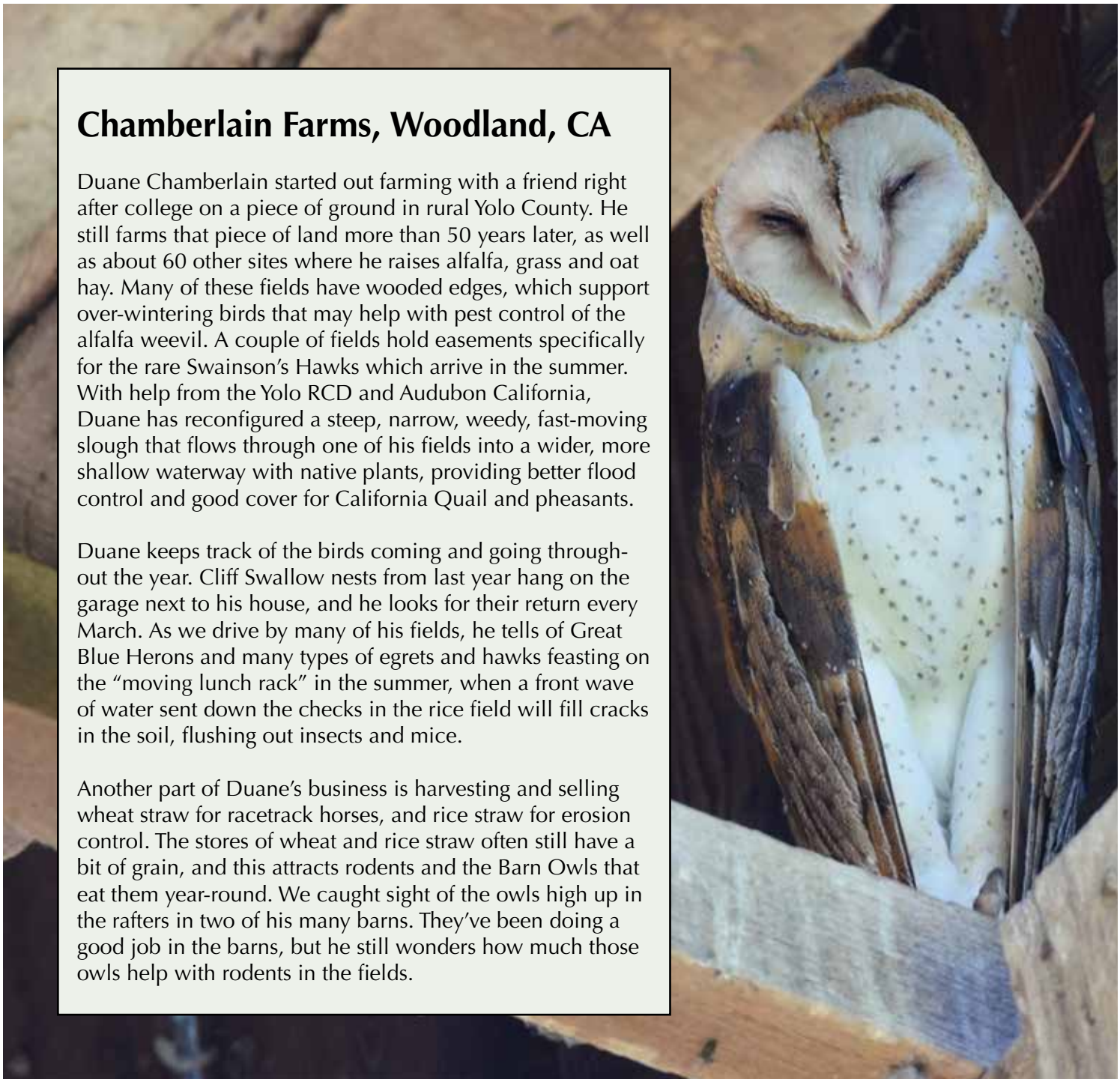
Depending on several factors, pest reduction by birds may or may not translate into improved yields. Low pest populations may not be enough to cause economic damage. Birds may not consume enough pests to reduce economic damage without additional IPM practices. Different beneficial species, such as insects and spiders, may be more effective at attacking the pests during the most susceptible time in pests' life cycles. It is also logistically difficult for researchers to study the effects of all potential beneficial animals at once; most often researchers isolate the effects of only a few. While effects of individual species might not measurably improve yields, it is hypothesized that the combined pest reduction by multiple natural enemy species might improve net yield.

Table 3. Noxious Seeds Eaten by Birds

From "Useful Birds" by S. A. Forbush (1908)

Amaranth *Amaranthus retroflexus*
Beggar-ticks *Bidens frondosa*
Bermuda Grass *Cynodon dactylon*
Bitter Dock *Rumex obtusifolius*
Black Bindweed *Fallopia convolvulus*
Blackberry *Rubus villosus*
Broom-sedge *Andropogon virginicus*
Bull Thistle *Carduus lanceolatum*
Chickweed *Stellaria media*
Climbing False Buckwheat *Polygonum scandens*
Crab Grass *Panicum sanguinalis*
Curled Dock *Rumex crispus*
Dandelion *Taraxacum taraxacum*
Giant Ragweed *Ambrosia trifida*
Green Foxtail Grass *Setaria viridis*
Jewel Weed *Impatiens*
Knotweed *Polygonum aviculare*
Lamb's Quarters *Chenopodium album*
Partridge Pea *Chamaecrista fasciculata*
Paspalum *Paspalum sp.*
Pennsylvania Persicaria *Polygonum pennsylvanicum*
Pigeon Grass *Setaria verticillata*
Pokeberry *Phytolacca decandra*
Poverty Grass *Aristida sp.*
Purslane *Portulaca oleracea*
Ragweed *Ambrosia artemisiifolia*
Rib-grass *Plantago lanceolata*
Sassafras *Sassafras albidum*
Sedge *Cyperus sp.*
Sheathed Rush-grass *Sporobulus vaginiforus*
Sheep Sorrel *Rumex acetosella*
Sneezeweed *Helenium autumnale*
Snowdrops *Oenothera fruticosa*
Sow Thistle *Sonchus oleraceus*
Spurge *Euphorbia maculata*
Sweet Clover *Melilotus alba*
Tick-trefoil *Desmodium nudiflorum*
Trumpet Creeper *Campsis radicans*
Wild Lettuce *Lactuca canadensis*
Yard grass *Eletisine indica*
Yellow Sorrel *Oxalis stricta*


Chipping Sparrow



Chamberlain Farms, Woodland, CA

Duane Chamberlain started out farming with a friend right after college on a piece of ground in rural Yolo County. He still farms that piece of land more than 50 years later, as well as about 60 other sites where he raises alfalfa, grass and oat hay. Many of these fields have wooded edges, which support over-wintering birds that may help with pest control of the alfalfa weevil. A couple of fields hold easements specifically for the rare Swainson's Hawks which arrive in the summer. With help from the Yolo RCD and Audubon California, Duane has reconfigured a steep, narrow, weedy, fast-moving slough that flows through one of his fields into a wider, more shallow waterway with native plants, providing better flood control and good cover for California Quail and pheasants.

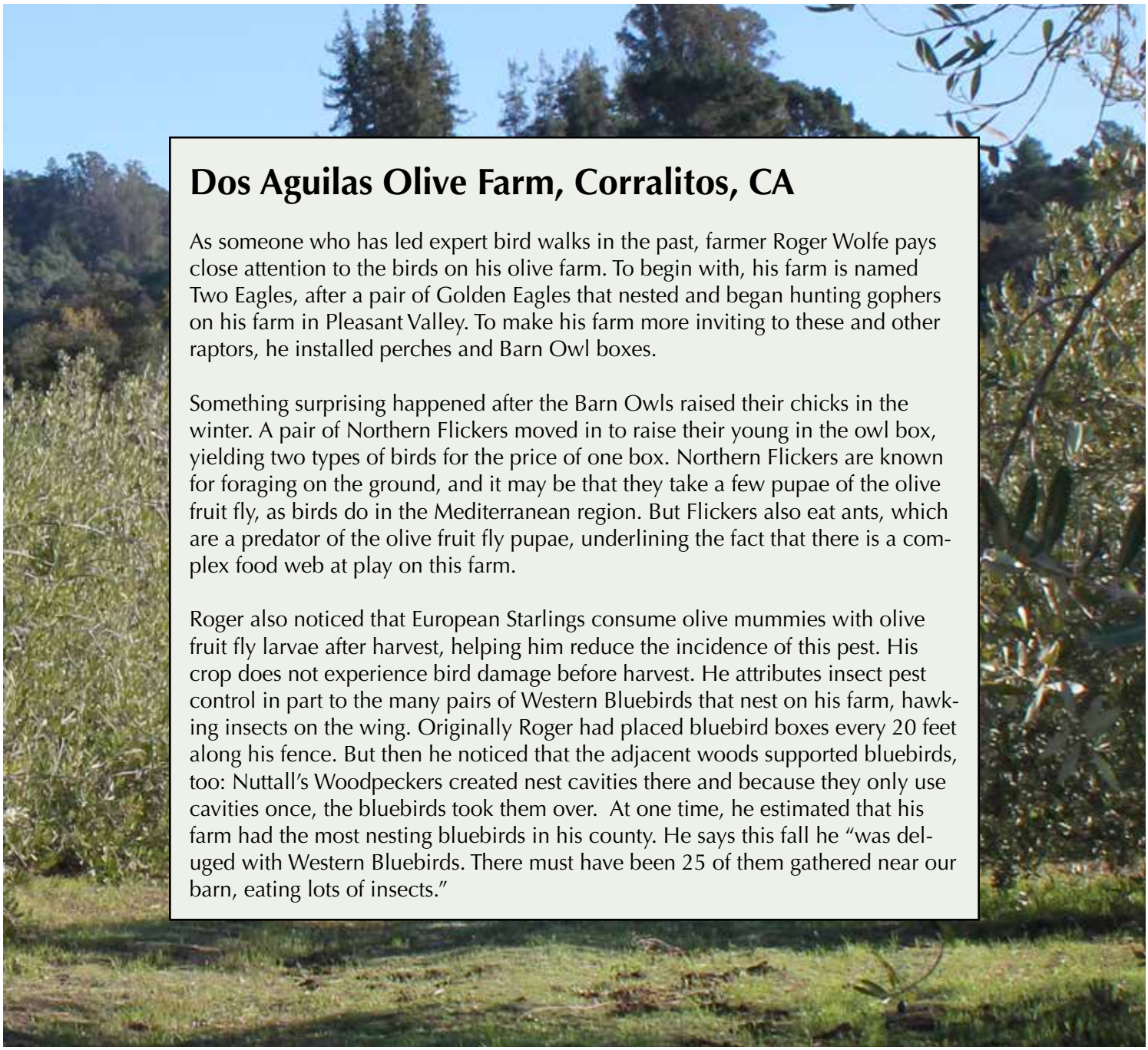
Duane keeps track of the birds coming and going throughout the year. Cliff Swallow nests from last year hang on the garage next to his house, and he looks for their return every March. As we drive by many of his fields, he tells of Great Blue Herons and many types of egrets and hawks feasting on the "moving lunch rack" in the summer, when a front wave of water sent down the checks in the rice field will fill cracks in the soil, flushing out insects and mice.

Another part of Duane's business is harvesting and selling wheat straw for racetrack horses, and rice straw for erosion control. The stores of wheat and rice straw often still have a bit of grain, and this attracts rodents and the Barn Owls that eat them year-round. We caught sight of the owls high up in the rafters in two of his many barns. They've been doing a good job in the barns, but he still wonders how much those owls help with rodents in the fields.

Studying How to Attract Birds to the Farm

Studies comparing various human-made bird attractants such as nest boxes, suet, and seeds attempt to determine simple and cheap means to improve bird numbers on farms. For example, suet has been found to increase avian predators of the Pear Psylla in pear orchards, while nest boxes placed in apple orchards attracted breeding birds which reduced Codling Moths and increased yields by 66%.

Many studies now take into account the influences of natural habitat on the farm and in the surrounding landscape. Hedgerows and edge habitat increase the presence of birds on the farm and, depending on the crop, may increase birds' pest-control services. The surrounding landscape that farmers don't control may also have significant influences. Whether an operation is surrounded by diverse cropping systems, monoculture, or complex natural habitats matters. The surrounding habitat can influence the abundance and diversity of birds and the interactions between them, other natural enemies, pests, and crops.



Dos Aguilas Olive Farm, Corralitos, CA

As someone who has led expert bird walks in the past, farmer Roger Wolfe pays close attention to the birds on his olive farm. To begin with, his farm is named Two Eagles, after a pair of Golden Eagles that nested and began hunting gophers on his farm in Pleasant Valley. To make his farm more inviting to these and other raptors, he installed perches and Barn Owl boxes.

Something surprising happened after the Barn Owls raised their chicks in the winter. A pair of Northern Flickers moved in to raise their young in the owl box, yielding two types of birds for the price of one box. Northern Flickers are known for foraging on the ground, and it may be that they take a few pupae of the olive fruit fly, as birds do in the Mediterranean region. But Flickers also eat ants, which are a predator of the olive fruit fly pupae, underlining the fact that there is a complex food web at play on this farm.

Roger also noticed that European Starlings consume olive mummies with olive fruit fly larvae after harvest, helping him reduce the incidence of this pest. His crop does not experience bird damage before harvest. He attributes insect pest control in part to the many pairs of Western Bluebirds that nest on his farm, hawking insects on the wing. Originally Roger had placed bluebird boxes every 20 feet along his fence. But then he noticed that the adjacent woods supported bluebirds, too: Nuttall's Woodpeckers created nest cavities there and because they only use cavities once, the bluebirds took them over. At one time, he estimated that his farm had the most nesting bluebirds in his county. He says this fall he "was deluged with Western Bluebirds. There must have been 25 of them gathered near our barn, eating lots of insects."

As time goes on, the studies are becoming more and more useful to farmers, helping them better understand what actions are needed to improve beneficial birds' effectiveness and to co-exist with pest birds. For farmers, the ultimate question is how this relates to the bottom line. We now know unequivocally that birds are a "tool" in the IPM toolbox that should be used and valued.

Wide-Spread Research of Birds in Agriculture

Research on birds as pest-control allies is occurring over much of the world, from the Americas and Europe to Africa and Australasia, and a great deal of the research looks at crops we grow in the U.S. Studies are currently being conducted by researchers in nine states (CA, WA, IL, AZ, NY, MI, CO, KY and MO). It takes an active and observant village to decipher the complexity of bird interactions on farms. Some researchers are steeped in entomology and others in conservation biology. They are all revealing the relationships between biodiversity and its benefits and costs, and how management can contribute to farm viability and bird conservation. Many researchers are also advocating for policy changes that better support farmers to implement these practices.

Table 4. List of Insect Pests and Birds Mentioned as Destroying Them

From "Local Suppression of Agricultural Pests by Birds," a Smithsonian Report (1920) by W. L. McAtee

Rocky Mountain Locust
Jack snipe (Wilson's Snipe)*, Curlews, Upland plover (Upland Sandpiper), Plovers, Quail (No. Bobwhite), Prairie-chicken, Blackbirds, Yellow-headed blackbird, Bobolink, Western meadowlark, Orioles, Sparrows, Robin (American Robin)

Mormon Cricket
California Gull

Coulee Cricket
Western Meadowlark

Periodical Cicada
Crow Blackbird (Common Grackle), English Sparrow (House Sparrow)

Rose Aphis (Rose Aphid)
White-crowned Sparrow

Plant Lice (Aphids)
Myrtle Warbler, Blackpoll Warbler, Oregon Chickadee (Black-Capped Chickadee)

Pea Louse
Chippy (Chipping Sparrow)

Pear Psylla
White-breasted Nuthatch

Black Olive Scale
Valley Quail (CA Quail)

Potato Beetle
Rose-breasted Grosbeak
Cliff Swallow

Asparagus Beetle
English Sparrow (House Sparrow)

Locust Leaf-miner
Yellow-billed Cuckoo, Kingbird (E. Kingbird), Great-crested Flycatcher, Phoebe (E. Phoebe), Wood Pewee (E. Wood Pewee), Orchard Oriole, Baltimore Oriole, English Sparrow (House Sparrow), Chippy (Chipping Sparrow), Field Sparrow, Song Sparrow, Chewink (E. Towhee), Cardinal, Scarlet Tanager, Cedar-bird (Cedar Waxwing), Red-eyed Vireo, Warbling Vireo, Yellow Warbler, Catbird (Grey Catbird), Carolina Wren

White Grub (June beetle)
Crow (Am. Crow), Robin (American Robin)

Elm Leaf-beetle
Cedar-bird (Cedar Waxwing)

Rose Weevil
Brewer's Blackbird

Orchard Tent-caterpillar
Yellow-billed Cuckoo, Blue Jay, Orchard Oriole, Cedar-bird (Cedar Waxwing)

Forest Tent-caterpillar
Yellow-billed Cuckoo
Baltimore oriole, English Sparrow (House Sparrow), Cedar-bird (Cedar Waxwing), Yellow Warbler, Robin (American Robin)

Tussock Moth
Hairy Woodpecker

Passion-vine Caterpillar
Roadrunner

Walnut Caterpillar
Yellow-billed Cuckoo

Canker-worm
Brewer's Blackbird, Baltimore Oriole, English Sparrow (House Sparrow), Warbling Vireo

Cabbage Worm
Chippy (Chipping Sparrow)

Cabbage Looper
Boat-tailed Blackbird (Green-Tailed Grackle)

Diamond-back Moth
Blackbirds

Cutworms
Starling, Western Meadowlark

Climbing Cutworm
Western Crow (Am. Crow)

Catalpa Sphinx
Yellow-billed Cuckoo,
Black-billed Cuckoo

Tomato Worm
Crow (Am. Crow)

Armyworm
Bronze Grackle (Common Grackle), Yellow-headed Blackbird, English Sparrow (House Sparrow)
Vesper Sparrow, Migrant Shrike (Loggerhead Shrike)

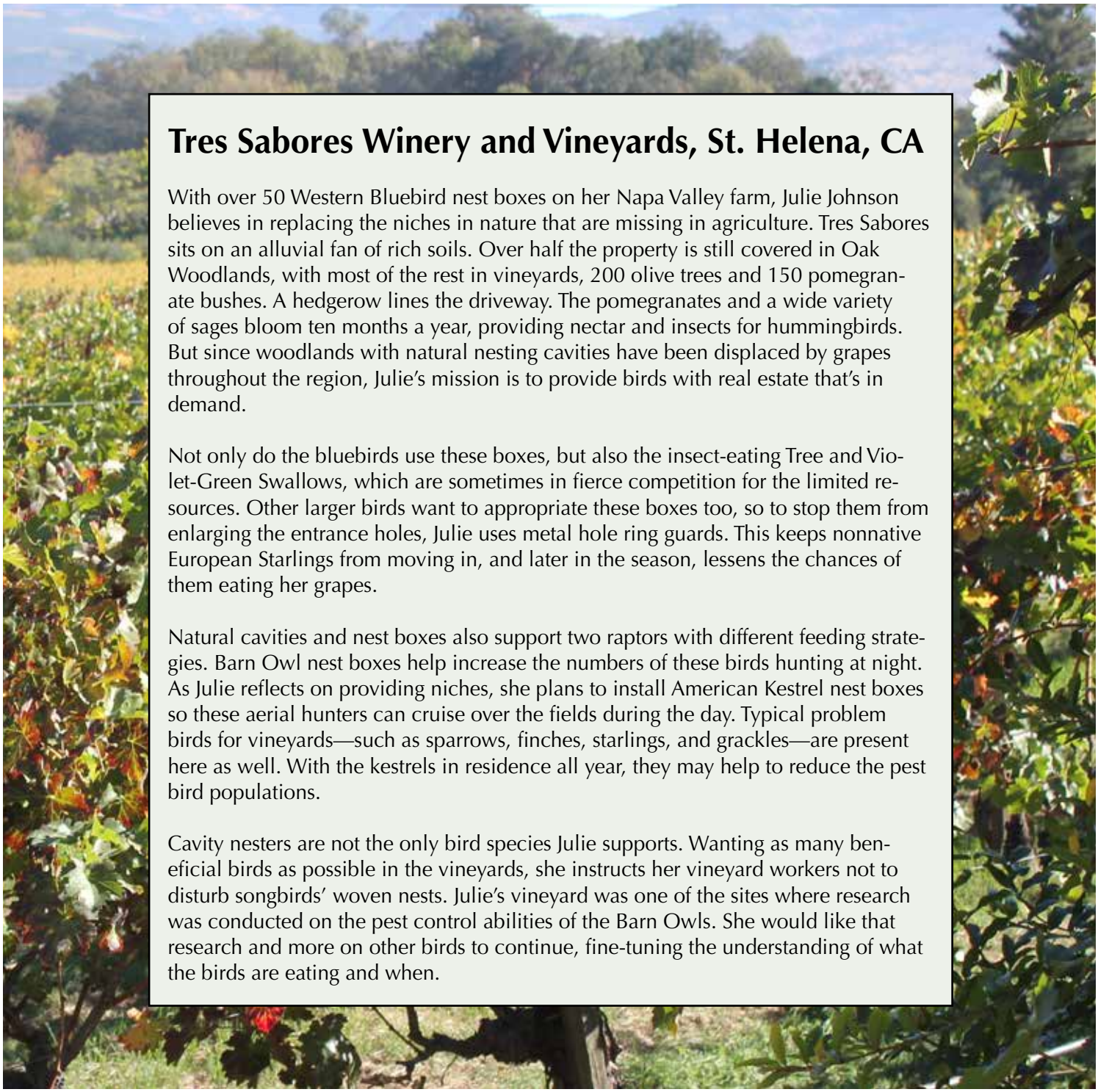
Drop Worm
English Sparrow (House Sparrow)

Cecropia Moth
Hairy Woodpecker

Codling Moth
Red-shafted Flicker (N. Flicker)

The current name of a bird is in parenthesis when the historic name is no longer used.

American Robin



Tres Sabores Winery and Vineyards, St. Helena, CA

With over 50 Western Bluebird nest boxes on her Napa Valley farm, Julie Johnson believes in replacing the niches in nature that are missing in agriculture. Tres Sabores sits on an alluvial fan of rich soils. Over half the property is still covered in Oak Woodlands, with most of the rest in vineyards, 200 olive trees and 150 pomegranate bushes. A hedgerow lines the driveway. The pomegranates and a wide variety of sages bloom ten months a year, providing nectar and insects for hummingbirds. But since woodlands with natural nesting cavities have been displaced by grapes throughout the region, Julie's mission is to provide birds with real estate that's in demand.

Not only do the bluebirds use these boxes, but also the insect-eating Tree and Violet-Green Swallows, which are sometimes in fierce competition for the limited resources. Other larger birds want to appropriate these boxes too, so to stop them from enlarging the entrance holes, Julie uses metal hole ring guards. This keeps nonnative European Starlings from moving in, and later in the season, lessens the chances of them eating her grapes.

Natural cavities and nest boxes also support two raptors with different feeding strategies. Barn Owl nest boxes help increase the numbers of these birds hunting at night. As Julie reflects on providing niches, she plans to install American Kestrel nest boxes so these aerial hunters can cruise over the fields during the day. Typical problem birds for vineyards—such as sparrows, finches, starlings, and grackles—are present here as well. With the kestrels in residence all year, they may help to reduce the pest bird populations.

Cavity nesters are not the only bird species Julie supports. Wanting as many beneficial birds as possible in the vineyards, she instructs her vineyard workers not to disturb songbirds' woven nests. Julie's vineyard was one of the sites where research was conducted on the pest control abilities of the Barn Owls. She would like that research and more on other birds to continue, fine-tuning the understanding of what the birds are eating and when.

Helping with Future Research

There are still many unanswered questions about birds as pest control allies. As farmers become more aware of the role birds play in their farm's food web, they can help direct and participate in on-farm research so that we can better understand why and how those connections work. Rather than each farmer dealing with an insect pest or rodent on their own farm, a whole region can work together. Growers in their commodity groups and regions can collaborate with researchers to discuss what we do and do not know, and the directions research should pursue. Researchers are currently working in nine states to decipher these issues. Advancing this knowledge helps farmers, birds and the biological diversity that sustains our world.

Impacts to Insects and Birds

Insects' Ranges and Numbers Are Changing

Every day farmers are presented with new scenarios due to climate change: increasing drought, heat waves and flooding, and a changing ecology. Insect flight periods are occurring earlier in the season, as are faster completions of life cycles, resulting in more generations of pests and enhanced winter survival. Insects' ranges are expanding north and higher in elevation, which will likely aid in the establishment and spread of invasive pest insects.

At the same time that insects' ranges are changing, their populations are also experiencing significant declines in many parts of the world. This is true for insects that provide pollination and pest control for crops and other plants in the landscape, decomposition, and food for birds. The declining diversity is thought to be caused by a changing climate, habitat loss and overuse of pesticides.

Birds' Distribution and Conservation Status Are Changing

Birds are in decline globally in a large part because of agricultural expansion and intensification that has replaced native habitats and degraded water sources. Agricultural expansion is the reason provided for the listing of about 74% of the globally threatened bird species. Other causes of decline are climate change, pesticides, cats, wires, vehicles and invasive species.

Bird distributions are also shifting to keep pace with the changing temperature zones, and this affects their nesting, migrations, and food sources. For example, beneficial Western Bluebirds, American Kestrels, and Barn Owls are predicted to lose 50% of their current range in 30 to 60 years. Others, such as Allen's Hummingbirds, which don't offer farms as much pest control services but can be supported by the farm habitat, stand to lose 90% of their range in the same time frame. While some birds will actually expand their range, the ranges of a majority of species are projected to decrease. When farmers increase bird habitat on their farms, they are making it more likely that birds will find the habitat that suits their needs as their ranges shift in the future.

Food Webs

How a specific farm's food webs and crop dynamics interact with a changing climate regime is hard to predict. However, it is prudent to plan for adaptations to a changing climate so that the farm is as resilient as possible to changing pest pressure. Ensuring that the farm supports beneficial birds is part of that.

What Harms Beneficial Birds on Farms and What You Can Do

Habitat Destruction

When habitat is reduced, there are fewer places for birds to feed, rest, escape predation, and reproduce. Conserve the native plants and natural water sources you have. Create habitat using NRCS practices listed in Table 2. If you mow, do it before or after the nesting season.

Climate Change

Climate change is impacting nesting, migrations, and the synchrony between birds, habitat and food sources. Because farm landscapes occupy a large footprint, when farmers provide food, water, cover, and nesting sites for birds, it makes it more likely that birds will find habitat suiting their needs in the future.

Pesticides

A single seed coated with a neonicotinoid can kill a songbird. Other pesticides affect birds' ability to stay warm, raise young and find food. Use IPM practices, including non-pesticidal ones, as often as possible, and see "Taking Care When Using Pesticides" on p. 38 for further help.

Cats

Cats kill birds. While farm cats may be valued for rodent control around buildings, their presence will lessen the number of birds on your farm. See suggestions about "Providing Predator Protection" on p.33 to reduce cats' impact on birds that use nest boxes. When feasible, keep cats indoors. If not possible, consider using the Birdsbesafe rainbow colored collar. Research shows that birds will likely see it with their keen color vision before being caught.

Wires and Water Troughs

Fence wires kill birds when they fly into them at high speeds. Birds drown in livestock water troughs when they come for a drink, fall in and can't climb out. Farmers can obtain assistance from NRCS to install fence markers that make the wires more visible, and escape ramps for troughs so birds and other wildlife have the traction to get out.

Cars and Trucks

Vehicle collisions are a huge killer of birds. Don't place raptor perches and nest boxes near busy roads. If you see road kill, move it off the road (if it is safe for you to do so) before a raptor or scavenger bird becomes a secondary kill.

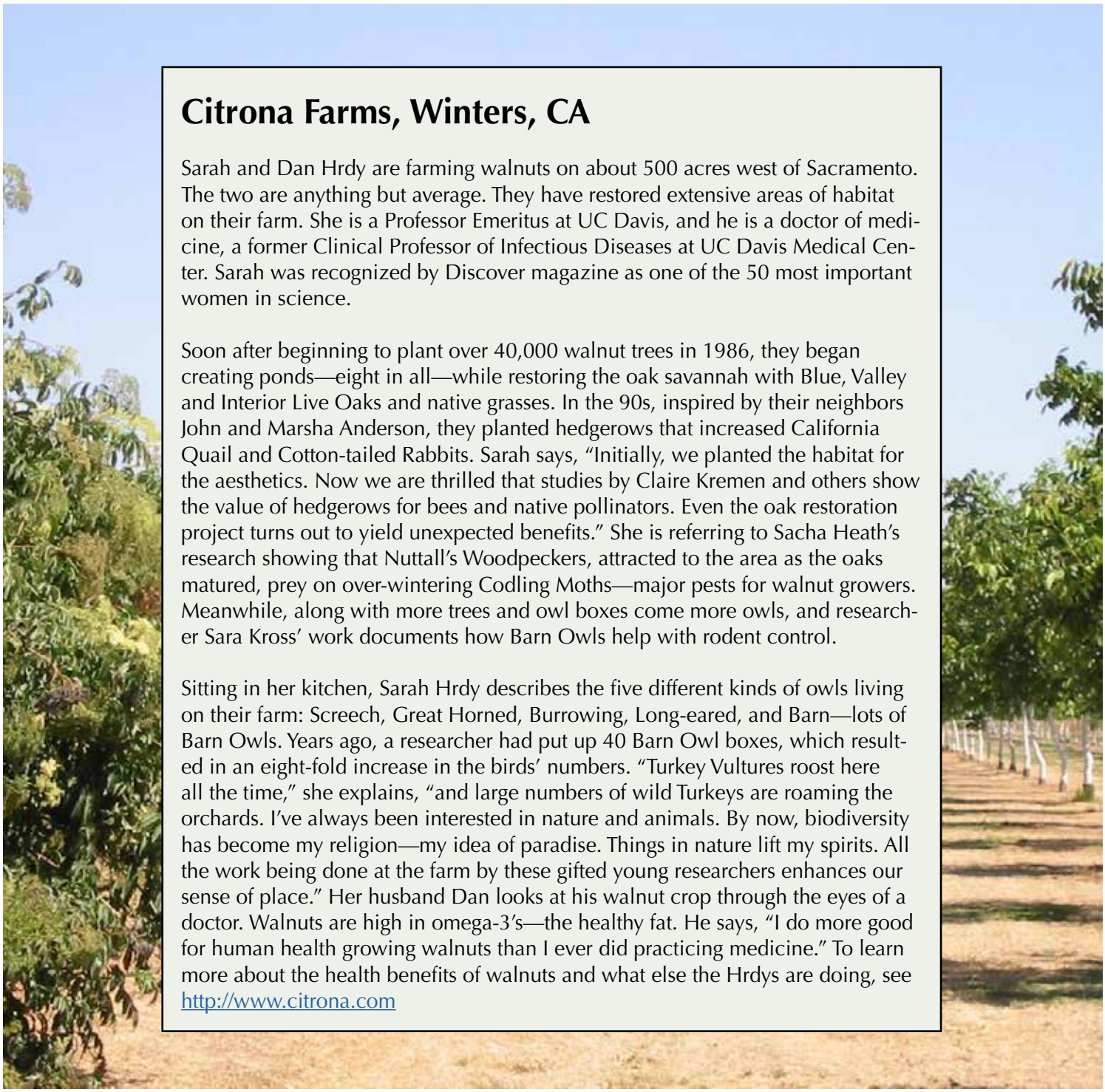
Invasive Species

Nonnative European Starlings and House Sparrows compete with native birds. To discourage them from using farm buildings and taking over nest boxes, see "Blocking Pest Bird Access to Farm Buildings" on p. 26, and "Putting Up Nesting and Perching Structures" on p. 31. Invasive plants crowd out native plants, resulting in less food for birds. Learn what invasive plants look like, remove them and proactively replace them with native plants.

Cats kill an estimated billion birds a year in the U.S. To reduce bird mortality, do not place nest boxes and perches near where cats reside, or use predator guards for structures.

Livestock water troughs can be deadly. Installing escape ramps saves birds' and other wildlife's lives.

Raptors and other birds can be killed by flying into fencing. Replacing barbed wire fencing as it breaks with smooth wire, and using fence markers, will lessen this occurrence.



Citrona Farms, Winters, CA

Sarah and Dan Hrdy are farming walnuts on about 500 acres west of Sacramento. The two are anything but average. They have restored extensive areas of habitat on their farm. She is a Professor Emeritus at UC Davis, and he is a doctor of medicine, a former Clinical Professor of Infectious Diseases at UC Davis Medical Center. Sarah was recognized by Discover magazine as one of the 50 most important women in science.

Soon after beginning to plant over 40,000 walnut trees in 1986, they began creating ponds—eight in all—while restoring the oak savannah with Blue, Valley and Interior Live Oaks and native grasses. In the 90s, inspired by their neighbors John and Marsha Anderson, they planted hedgerows that increased California Quail and Cotton-tailed Rabbits. Sarah says, "Initially, we planted the habitat for the aesthetics. Now we are thrilled that studies by Claire Kremen and others show the value of hedgerows for bees and native pollinators. Even the oak restoration project turns out to yield unexpected benefits." She is referring to Sacha Heath's research showing that Nuttall's Woodpeckers, attracted to the area as the oaks matured, prey on over-wintering Codling Moths—major pests for walnut growers. Meanwhile, along with more trees and owl boxes come more owls, and researcher Sara Kross' work documents how Barn Owls help with rodent control.

Sitting in her kitchen, Sarah Hrdy describes the five different kinds of owls living on their farm: Screech, Great Horned, Burrowing, Long-eared, and Barn—lots of Barn Owls. Years ago, a researcher had put up 40 Barn Owl boxes, which resulted in an eight-fold increase in the birds' numbers. "Turkey Vultures roost here all the time," she explains, "and large numbers of wild Turkeys are roaming the orchards. I've always been interested in nature and animals. By now, biodiversity has become my religion—my idea of paradise. Things in nature lift my spirits. All the work being done at the farm by these gifted young researchers enhances our sense of place." Her husband Dan looks at his walnut crop through the eyes of a doctor. Walnuts are high in omega-3's—the healthy fat. He says, "I do more good for human health growing walnuts than I ever did practicing medicine." To learn more about the health benefits of walnuts and what else the Hrdys are doing, see http://www.citrona.com

Farmers—Tell Your Story and Be Part of WFA's Story Map

By telling your stories, you can help each other understand how you benefit from and co-exist with birds. You can also help the environmental conservation movement—supported by the hearts and minds of millions of people—to understand that, yes, economics are vital to a farm, as well as supporting birds and other biodiversity on our finite planet. Your practices, along with large scale conservation efforts of others, increase the number of birds controlling pests, and helps avian species remain viable.

Be part of WFA's Story Map, an online site that combines your images and text into a map of our farmscapes. Help us harness the collective power of farm innovation that supports nature. www.wildfarmalliance.org/storymap

Farmer and Consumer Perceptions

What Farmers Think about Birds

According to a recent California survey, most farmers think perching birds and raptors are beneficial for pest control. Organic farmers view these birds more positively than do conventional growers, and women farmers view them more positively than do men farmers.

Fruit farmers view "perching birds" negatively. It is important to note that about half of all bird species in the world are perching birds —ornithologists also call them "passerines" or sometimes "songbirds". The majority of bird damage to fruit crops is caused by only a few species, while many perching birds are insectivores and are beneficial to growers. For example, flocking birds such as starlings are known consumers of fruit crops, while warblers, chickadees, and nuthatches forage on caterpillars that damage fruits. Planting and conserving habitat to support beneficial birds while managing the species that most damage crops is a win-win for birds and for farmers.

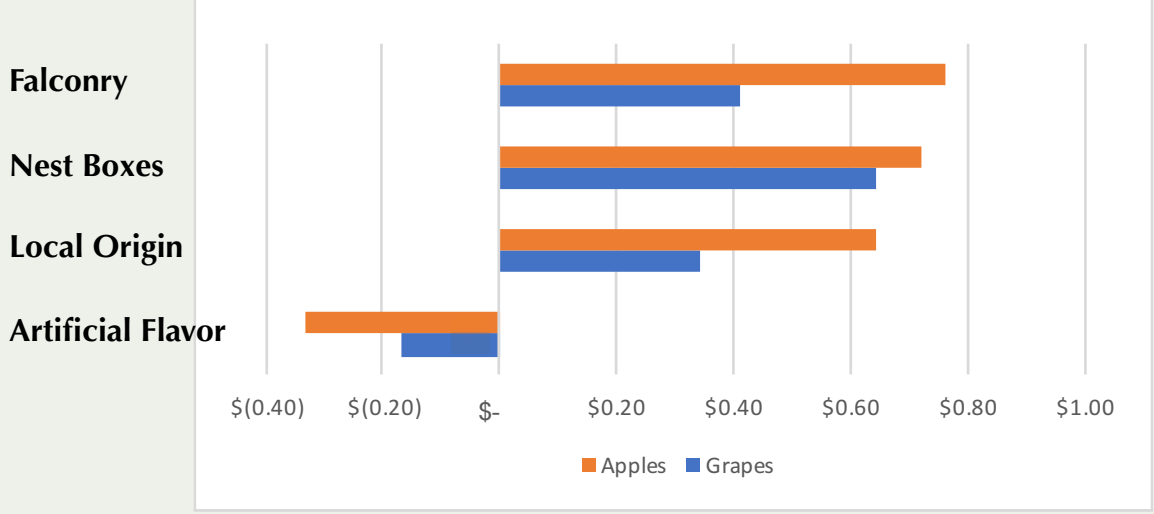
What Some Fruit Growers Do to Support Birds

About 38% of cherry and blueberry growers across the country are already using American Kestrel nest boxes. In a nationwide farmer perception survey, all growers responded that they were interested or very interested in using nest boxes and in working to market their use of this practice to consumers (for example, "bird friendly cherries"). Additionally, many of these growers use other conservation practices such as mowing to expose rodents, supporting and monitoring beneficial insects, and increasing pollinator habitat.

Consumers Would Pay More for Fruit Grown with Conservation Practices

Although farmers perceive that consumers care more about purchasing "local" produce than about supporting conservation practices, a national survey of consumers found the opposite. Apple and grape customers responded that they would pay an average of U.S. $0.41–0.76 per pound more for fruit grown with natural practices (see Figure 2 below). This survey addresses a point many growers make: that if society appreciates stewardship, they will be willing to help pay for it.

Figure 2. Consumers Would Pay More for Conservation Practices



Consumers of apples and grapes are willing to pay more for falconry, nest boxes and locally grown fruit, compared to non-local fruit and shooting birds. They would pay less for fruit with artificial flavoring.[1]

[1] After Oh et al. 2015.

Appendix A. Beneficial Bird Actions & Bird Management Studies

Legend of Beneficial Actions (for Left-hand Column)

Black Text=Birds Reduced Pests
Purple Text=Birds Decreased Damage, and Increased Growth, Yield, or Savings
Blue Text=Other Natural Enemies Reduced Pests
Green Text=Ecosystem Interactions
Orange Text=No Bird Benefit
Red Text=Bird Caused Damage or Consumed Other Natural Enemies

Sections

I. Pest Insects & Other Invertebrates Managed with Beneficial Birds
II. Pollination Managed with Beneficial Birds
III. Unwanted Plant Material (Weeds or Too Much Biomass)
IV. Pest Rodents
V. Pest Birds Managed with Beneficial Birds
VI. Pest Birds Managed with Alternative Practices

I. Pest Insects & Other Invertebrates Managed with Beneficial Birds

Beneficial Action by Birds	Effects of Habitat (Plants, Nest Boxes, Perches)	Beneficial Birds	Insect & Other Arthopod Pests or Experimental Prey	Reference
Vegetables				
Broccoli				
Birds Most Important with Reducing Pests and Increasing Plant Growth, But Spiders Helped		No.- and Red-crested Cardinals	*Trichoplusia* and *Artogeia larvae*	Hooks et al. 2003
Increased Pest Insects & Decreased Natural Enemy Insects and Spiders But Did Not Impact Yield	Esp. in Simple Landscapes Toward the End of the Growing Season	Swallows and Sparrows	Aphids, Caterpillars and Flea Beetles	Smith et al. 2018 (per. com.)
Cabbage				
More Bird Activity With More Pest Insects		14 Indian Bird Species	Cabbage Aphids	Jadav et al. 2013
Birds and Other Natural Enemies Decreased Infestation	Esp. with Complex (Forest and Riparian) Landscapes	Wild Birds in South Korea	Aphids	Martin et al. 2015
Reduced Pest Insects by 49%		Savanna Sparrows	Experimental Cabbage Loopers	Strandberg 1981
Hops				
Reduced Pest Insects Somewhat But Other Natural Enemies Were More Important		Wild Birds of Washington	Hop Loopers	Grasswitz & James 2011
Kale				
Reduced Experimental Prey (Caterpillars) by 24% on Average	Esp. Near Hedgerows	Am. Robins and CA Scrub-jays	Live Experimental Cabbage Looper	Garfinkel & Johnson 2015
No Reduction of Pest Insects But Infestation Low		Am. Robins and CA Scrub-jays	Caterpillars Naturally Present	Garfinkel & Johnson 2015
Reduced Pest Insects; Did Not Reduce Aphid's Natural Enemies	Esp. Near Shade Trees	East African Birds	Live Aphids and Caterpillars and Fake Caterpillars	Guenat 2014
Reduced Pests Insects by 57%; Decreased Plant Damage by 67%		East African Birds	Aphids and Thrips	Ndang'ang'a et al. 2013a
Mixed Crops				
Reduced Pest Insects without Crop Damage	Esp. Near Sunflower Perches, and in Mixed Crops and Diverse Landscapes	N. Cardinals, E. Bluebirds, N. Mockingbirds, Orchard Orioles, E. Bluebirds and Summer Tanagers	Cabbage worms, Blue Flea Beetles, Seed Bugs, Grasshoppers	Jones et al. 2005a, Jones et al. 2005b, Jones & Sieving 2006
Birds Reduced Other Natural Enemies	Increasing Diversity from Simple Landscapes to Forest Cover Led to Birds Foraging on Other Natural Enemies Possibly Due to High Densities of Each	South Korean Birds	Lepidopteran larvae, Cabbage and Green Peach Aphids	Martin et al. 2013
Potential for Pest Control Due to Aerial and Ground Foraging Behavior		Aerial and Ground Foraging Birds of East Africa	Invertebrates, Weeds, Rodents	Ndang'ang'a et al. 2013b

Beneficial Action by Birds	Effects of Habitat (Plants, Nest Boxes, Perches)	Beneficial Birds	Insect & Other Arthopod Pests or Experimental Prey	Reference
Fruit				
Apples - also see Pest Rodents				
Reduced Overwintering Pest Insects by 77-91%; Natural Enemies Somewhat Important	More Bird Species Diversity Near Native Habitat	CA Scrub and Stellar's Jays, Am. Robins, EU Starlings, Ruby-crowned Kinglets, N. Flickers, Downy Woodpeckers, Oak Titmice, Brewer's Blackbirds and Chestnut-backed Chickadees	Live Experimental Codling Moth Larvae	Baumgartner 1999, 2000
Reduced Mainly Aphid Pests and Some Natural Enemies But Without Constraining on Pest Control	More Species Abundance and Diversity Near Shrubby Habitat	EU Robins, Common Blackbirds, EU Blackcaps, EU Wrens, Great and EU Blue Tits	Aphids, Apple Blossum Weevils and Other Arthropods	Garcia et al. 2018
Reduced Overwintering Pest Insects by > 90%		Wild Birds of Ontario	Codling Moths	Hagley 1970
Reduced Overwintering Pest Insects by 55%		Wild Birds of Quebec	Codling Moths	Mailloux & LeRoux 1960
No Reduction of Spring/Summer Pest Insects in Organic Orchards but Pest Population Was Low; Birds Caused Little Direct Damage	Organic Orchards and Adjacent Hedgerows Contained a Large Number of Bird Species	Birds Present But Not Necessarily Beneficial: Am. Robins, Brewer's Blackbirds, Cedar Waxwings, House Finches, Lewis' Woodpecker, Blue Grosbeak and Lesser Goldfinch	Codling Moths	Mangan et al. 2017
Reduced Overwintering Pest Insects by 52% (Below Economic Threshold)	Esp. Near Native Forest	Hairy and Downy Woodpeckers	Codling Moths	MacLellan 1958, 1959, 1961
12 Bird Species Found with Codling Moths in Their Stomachs		Most Important Birds: Downy Woodpeckers, Bullock's Orioles, Black-headed Grosbeaks and Bush Tits	Codling Moths	McAtee 1911
Reduced Pest Damage by 11-14%; Increased Yield by 66%	Used Nest Boxes	Great Tits	Codling Moths	Mols & Visser 2002, 2007
Reduced Pest Insect Damage by ~ 13%, Caused ~ 2% Crop Damage, Resulting in a Net Benefit	More Species Diversity Near Native Habitat Patches	36 Native Birds and 3 Nonnative Birds in AU	Real Codling Moths, Fake Caterpillars	Peisley et al. 2016
Reduced Pest Insects; the More Pests - the Higher Consumption Rates		Pine Siskins	Winter Moths	Roland 1994, Roland et al. 1986
Reduced Pest Insects but Did Not Increase Yields Due to Complex Environmental Factors		AU Birds	Codling Moths	Saunders & Luck 2016
Reduced Overwintering Pest Insects by 94-99%		Great and Blue tits, Tree-creepers, Woodpeckers and Nuthatches	Live Experimental Codling Moth Larvae	Solomon et al. 1976, Solomon & Glen 1979
Reduced Overwintering Pest Insects by ~90%		White-breasted Nuthatches and Brown Creepers	Codling Moths	Stairs 1985
Reduced Pest Insects by 35-67%; the More Pests - the Higher Consumption Rates		Silvereyes	Codling Moths	Wearing & McCarthy 1992
Reduced Overwintering Pest Insects by 46-99%		Great Tits	Live Experimental Codling Moth Larvae	Zajac 1980
Cacao				
Reduce Pest insects; A Single, Abundant Insect-eating Bird Species Can Be Effective, Rather Than Many Bird Species	Predation increases with proximity to forest	Lemon-bellied White-eyes	Fake Caterpillars	Maas et al 2015
Reduced Pest Insects which Increased Yield by 31%		Indonesia Birds Including Flowerpeckers, Sunbirds and White-eyes	Arthopods	Maas et al 2013
Reduced Large and Small Arthropods; Reduced Leaf Damage; The More Migratory Bird Species, the More the Predation		27 Panamian Birds Foraging on Insects	Arthopods	Van Bael et al. 2007
Cherries - see Pest Birds				

Beneficial Action by Birds	Effects of Habitat (Plants, Nest Boxes, Perches)	Beneficial Birds	Insect & Other Arthopod Pests or Experimental Prey	Reference
Coffee				
Reduced Large Pest Insects by 64-80%; Reduced Damage	Shade Did Not Effect Predation	Guatemalan Birds Foraging on Insects	Arthopods	Greenberg et al. 2000
Reduced Leaf Damage by 28%; Saved Farmers $310/ha	Esp. with in Shade and Surrounding Habitats	24 Jamaican Birds Foraging on Insects	Coffee-berry Borers and Other Arthopods	Johnson et al. 2010
Reduced Pest Insects Substantially	Pest Contol Benefit Increased as Habitat Patch Sizes Increased	5 Brazilian Birds Foraging on Insects	Fake Caterpillars	Jordani et al. 2015
Reduced Pest Insects by 50%; Saved Farmers $75–310/ha,	Farmland Forest Cover Increased Pest Control	5 Costa Rican Birds Responsible for Most of the Benefit	Coffee-berry Borers	Karp et al. 2013
Reduced Pest Insects by 1-14%; Reduced Damage; Saved $44–105/ha	3 Bird Species Responded to Habitat	17 Jamaican Birds Foraging on Insects	Coffee-berry Borers	Kellerman et al. 2008
Reduced Pest Insects Significantly	More with Increasing Nearness to Habitat	36 Kenyan Birds Foraging on Insects	Live Experimental Maize Stemborer Caterpillars	Milligan et al. 2016
Reduced Pest Insects	Esp. in More Complex Shade Grown Coffee	Mexican Warblers, Wrens and Vireos	Lepidopteran Sentinel Caterpillars	Perfecto et al. 2004
The More Insect-Eating Bird Species, the More Predation of Pests		Central American Birds Foraging on Insects	Arthopods	Philpott et al. 2009
Feijoa - see Pollination				
Loquat - see Pollination				
Mayple Sugar Bushes				
Reduce Pests Enough that Damage Was No Longer Noticed		Warblers, Orioles, Sparrows, Robins, Cedar 'Birds' and House Wrens	Tent Caterpillars	Forbush 1908
Reduced Pest Insects and Leaf Damage But Did Not Increase Biomass Production		New Hampshire Forest Birds	Lepidoptera larvae	Strong et al. 2000
Olives				
Reduced Pupae in Soil by 65-71%; Ants Somewhat Important Predator		Birds of Greece	Olive Fruit Flies	Bigler et al. 1986
Reduced Pest Insects Significantly		Birds of Italy	Olive Fruit Flies	Cavalloro & Delrio 1975
Oranges				
Reduced EU. Earwig; Ants More Important Predator		EU Starlings, House and Tree Sparrows	EU Earwigs (Sometimes a Pest)	Pinol et al. 2010
Pears				
Sizeable Pest Insect Reduction		Dark-Eyed Juncos	Pear Psyllas	Fye 1982
Stomachs of Birds Contained Pest	Only the Black-capped Chickadees Used Feeding Stations with Suet, Seeds and Grain	Most Important Birds: Black-capped Chickadees, Golden-crowned Kinglets and Red-breasted Nuthatches	Pear Psyllas	Odell 1927
Strawberries				
Reduced Insect Damage (3.8%) at about the Same Rate as Pest Birds Created Damage (3.2%)	Highest Abundance of Birds with Habitat on the Farm and in the Surrounding Landscape	Insect-eating Birds (eg. Black Phoebes, Pacific-slope Flycatchers) and Fruit-eating Birds (eg. House Finches, Am. Robin, EU Starling)	Mainly Lygus Bugs, But Also Leaf-rollers and Slugs	Gontheir et al. 2018
Wine Grapes - also see Pest Rodents and Pest Birds				
Reduced Pest Insects Substantially	Esp. in Vineyards with Semi-natural Habitat	EU Blackbirds, Tits, Common Chaffinch, Blackcaps and Common Redstarts	Fake Caterpillars	Barbaro et al. 2017
Reduced Pest Insects 1/3rd More Near Nest Boxes in Winegrapes and also in Peaches, Prunes, Pears	Level of the Nest Boxes and Patchiness of Habitat Strongly Affected Box Use and Number of Eggs and Chicks	Great Tits, House and Tree Sparrows	Live Experimental Greater Wax Moth Caterpillars	Benayas et al. 2017
Reduced Pest Insects by 32-98%; Highest Rates During Mid-Summer	No Difference Between Interior and Edges of Vineyard	W. Bluebirds, Dark-eyed Juncos, CA Scrub Jays	Live Experimental Mealyworms	Howard & Johnson 2014
Reduced Pest Insects by 58%; Consumed Only 3% Natural Enemies	Pest Control Esp. Near Nest Boxes	W. Bluebirds, Chipping Sparrows, Am. Goldfinches & Other Insect-Eating Birds	Live Experimental Beet Armyworms	Jedlika et al. 2011 and 2017

Beneficial Action by Birds	Effects of Habitat (Plants, Nest Boxes, Perches)	Beneficial Birds	Insect & Other Arthopod Pests or Experimental Prey	Reference
Reduced Pest Insects in 1 Vineyard More So Than Birds Decreased Natural Enemy Insects and Spiders	Esp. Near Nest Boxes	W. Bluebirds	Mainly Leafhoppers	Jedlika et al. 2014
Nut Crops				
Almonds - also see Pest Bird Alternative Management				
Birds and Other Vertebrates Reduced Pest Insects by 2% to 96% per Orchard	Esp. Near Natural Habitat and with Increased Plant Species in the Understory	Am. Crow, Scrub-jay and Yellow-billed Magpie	Navel Orangeworms	Eilers & Klein 2009
Cost Effectively Reduced Mummified Nuts Even Though Birds Also Caused Damage; Predicted Positive Net Return of AUD$25–$275/HA	Bird Activity Esp Near Edges	Ravens, Parrots, and Cockatoos	Insects or Disease in Mummified Nuts	Luck 2014
Pecans				
Reduced Various Pest Insects		US Birds	64 Bird Species Prey on Weevils, > 60 Species on Plant Lice and Scale, 45 on Bark Beetles, 13 on Termites, 5 Each on Webworm and Hickory Borer	Tedders 1983 (*In* McAtee 1915)
Reduced 2,100 Pest Insects Per Bird with an Estimated Savings of $2,900		Tufted Titmices	Pecan Nut Casebearer Larvae	Whitcomb 1971
Walnuts				
Reduced Pest Insects During their Winter Phase by 41% on Average	Increased from 23% to 65% as Woodlands, Grasslands, and Woody Plantings Increased in the Landscape from 0% to 38%.	Nuttall's Woodpeckers, Red-breasted Sapsuckers, N. Flickers, Acorn Woodpecker, White-breasted Nuthatches, Oak Titmouse, Bushtit, Hermit Thrush, Bewick's Wren and Yellow-billed Magpie	Live Experimental Codling Moth Larvae	Heath 2018 & Heath et al. 2017
Grasslands & Pastures				
Grasslands				
Reduced Insect Pests by 55%	E. Meadowlarks	Grasshopper, Cassin's and Botteri's Sparrows	Grasshoppers	Bock et al. 1992
Reduced Insect Pests by 26-37%		No. Dakota Grassland birds	Grasshoppers	Fowler et al. 1991
Reduced Insect Pest Densities by 25-27%		Nebraska Grassland birds	Grasshoppers	Joern 1986 & 1992
Pastures - also see Unwanted Plant Material				
Reduced Insect Pests by 40-60%		EU Starlings	Grass Grubs	East & Pottinger 1975
Field Crops				
Alfalfa				
Reduced Pests by 100 Insects Per Day Per Hawk in Alfalfa and Corn	Birds Roosted in Small Stands of Cottonwoods Nearby	Swainson's Hawks	Grasshoppers	Johnson, et al. 1987
Reduced Insect Pests by >33%; As Bird Abundance Increased, Pests Decreased	Esp. Near Trees on Edges	Savannah Sparrows, Red-winged Blackbirds, Am. Pipits, Am. Crow, Swallows (Cliff and Tree), and W. Meadowlarks	Alfalfa Weevils	Kross et al. 2016
Corn - also see Pest Bird Alternative Management				
Prevented 34% Crop Damage	High Bird Diversity Supported by Surrounding Forest	Hairy Woodpeckers	Corn Earworms & Fall Armyworms	Barber 1942

Beneficial Action by Birds	Effects of Habitat (Plants, Nest Boxes, Perches)	Beneficial Birds	Insect & Other Arthopod Pests or Experimental Prey	Reference
Reduced Insect Damage by 20% at Same Rate as Pest Birds Created 20% Damage		Red-winged blackbirds	EU Corn Borers	Bendell et al. 1981
Reduced Overwintering Pest Insects by 64-82%		N. Flickers	So. Corn Borers	Black et al. 1970
Reduced Insect Damage by 50% in Early Stage of Planting; Caused 80% Crop Damage Later On		Red-winged Blackbirds	No. Corn Rootworm Beetles	Bollinger & Caslick 1985a, 1985b
Reduced Overwintering Pest Insects by 90%		Yellow-shafted Flickers	So. Corn Borers	Floyd et al. 1969
Reduced Overwintering Pest Insects by 34%: Other Natural Enemies Reduced Pests by 41%		Downy Woodpeckers	EU Corn Borers	Fye 1972
8-64% of Stomachs Contained These Listed Pest Insects and Relatively Few Natural Enemy Insects Were Eaten; Whereas 9% of the Stomachs Contained Corn		E. Meadlowlarks	Pillbugs, Spittlebugs , Striped Grass Loopers, Cutworms, Grasshoppers, and Click Beetles and Wireworms	Genung & Green 1974
6-35% of Stomachs Contained These Listed Pest Insects and 1-7% Contained Each Natural Enemy Insects; Whereas 41% Contained Corn		Red-winged Blackbirds	Elaterid Beetles, Fall Armyworms, Corn Earworms, Ants, Spittlebugs, So. Gr. Stinkbugs, Grasshoppers	Genung et al. 1976
Most Important Food for Song Sparrow Nestlings Was Hoppers and Caterpillars	Nestling Insect Diet Was More From Hedgerows Than From Corn or Soybeans	Song Sparrows	Hoppers, Caterpillars	Girard et al. 2012
High Number of Foraging Events	Esp. Within 20 Meters of Shelterbelts and Riparian Areas	E. Bluebirds, Gray Catbirds, Brown Thrashers, Lark and Song Sparrows, N. Cardinals and Am. Goldfinches	Invertebrates	Puckett et al. 2009
Reduced Overwintering Pest Insects by 50%		Am. Crows	EU Corn Borers	Quiring & Timmins 1988
Reduced Insect Pests; No Effect on Crop Yield, But Infestation Was Low	Esp. Within 7 Meters, But Some Up To 25 Meters, of Habitat Patches	Red-winged Blackbirds, Am. Robins, Song and Chipping Sparrows and Other Omnivorous and Insect-eating Birds	EU corn Borer, Cutworms, Weevils and Corn Leaf Aphids	Tremblay 1999 & Tremblay et al. 2001
Reduced Overwintering Pest Insects by 2-55%	Esp. Near Woodlands	Downy Woodpeckers, N. Flickers	So. & EU Corn Borers	Wall & Whitcomb 1964
Cotton				
Attacked 2-4% of Pest Insects per Day		Ugandan Birds	Fake Caterpillars	Howe et al. 2015
28 Bird Species Found with Significant Number of Boll Weevils Their Stomachs		Most Important Birds: Orioles, Blackbirds, Meadlowlarks, Painted Buntings, Quail, Morning Doves & Mockingbirds	Cotton Boll Weevils	Howell 1906
Dried Beans				
Reduced Pest Insects by 84%, Increased Yields by 71%; Live Plant Perches Resulted in a Larger Benefit Than Using Pesticides in Chickpeas	Used Sunflower and Sorghum Perches, Which Also Increased Numbers of Natural Enemy Insects	Sparrows, Baya's, Mynahs, and Black Drongos	Bollworm/Pod Borer	Gopali et al. 2009
Reduced Pest Insects by 62-64%, Increased Yields by 70-89% in Chickpeas	Used Artificial "T" Perches	Cattle Egrets, House Sparrows, Common and Bank Mynas and Black Drongos	Bollworm/Pod Borer	Khinchi & Yadav 2014
Reduced Pest Insects, Increased Yields by 28% in Chickpeas	Esp. with Intercrops Which Serve As Live Bird Perches	Indian Birds	Bollworm/Pod Borer	Shivaleela 2012
Reduced Pest Insects, Yields Increased 39% Where the Highest Number of Bird Species Were Present in Field Beans	Esp. with Multiple Cropping Patterns	House Crows, Black Drongo and Golden Oriole	Bollworm/Pod Borer	Chakravarthy 1992
Reduced Pest Birds Substantially in Pigeon Peas		Jungle Babbler	Bollworm/Pod Borer	Bharucha & Padate 2010

Beneficial Action by Birds	Effects of Habitat (Plants, Nest Boxes, Perches)	Beneficial Birds	Insect & Other Arthopod Pests or Experimental Prey	Reference
Millet				
Reduced Pest Insects by 20-26% According to Model		Senegalese Birds, Including Cattle Egrets, Sparrows, Rollers, Buzzards	Senegalese Grasshoppers	Axelsen et al. 2009
40 Bird Species with Significant Number of Armyworms their Stomachs, in Millet and Other Grain Fields		Grackles, Yellow-headed Blackbirds, Chipping Sparrows, Bluebirds, Prairie Hens and EU Starlings	Armyworms	Walton 1916
Oil Palm				
Reduced Damage to Young Plants		Oriental Magpie Robin, Ashy Tailor Birds and Greater Coucal	Several Caterpillars	Koh 2008
Oilseed Rape				
Birds Weakly Decreased Leaf Damage; Other Natural Enemies Were More Important	Weak Pest Control of Birds Related to Tree Cover	Ethiopian Birds	Cabbage Flea Beetles, Aphids, Lepidopteran Skeletonizers and Chewing Larvae	Lemessa et al. 2015
18-84% of Prey Consumed Were Crop Pests		Common Swifts, Barn Swallows, and House Martins	Cabbage Seedpod Weevils and Pollen Beetle Pests	Orlowski et al. 2014
Rice- also see Unwanted Plant Material				
Birds Did Not Decrease Pest Insects; Birds Caused 3-32% Damage But Did Not Impact Yield		Red-winged Blackbirds	Stink Bugs	Borkhataria et al. 2012
Reduced Insect and Snail Pests	Esp. with Perches & High Diversity Vegetation Patches	Shrikes, Grassbirds and Kingfishers	Grasshoppers, Caterpillars and Golden Apple Snails	Horgan et al. 2017
Removed 89% of Snails		Pastured Ducks	Golden Apple Snails	Naylor 1996
Sunflowers - see Pest Bird Alternative Management				
Tea				
Reduced Pest Insects		Indian Birds (Asian-pied Starling, Chestnut-tailed Starling, Jungle Myna and Red-vented Bulbul	Geometrid Looper Caterpillars	Sinu 2011
Tobacco				
Consumed between 59-100% of Pest Insects Placed on Plants		Common Grackles	Tobacco Hornworm	Thurston & Prachuabmoh 1971
Reduced 44-53% of Pest Insects		Am. Crows, Mockingbirds, E. Bluebirds and House Sparrows	Tobacco Hornworm	Stewart 1975
Wheat - also see Unwanted Plant Material and Pest Rodents				
Increased Pest Insects and Decreased Natural Enemy Insects in Wheat and Oats		Tree Sparrows	Cereal Aphids	Grass et al. 2017
34-70% of Two Birds Species Contained Mostly Caterpillars; They Also Consumed Wheat		Horned Larks and McCown's Longspur	Pale Western Cutworms, Grasshoppers, Ants and Beetles	McEwen et al. 1986
Reduced Pest Insects by 34%		Indian Birds (Bank Myna, Black Drongo, Rosy Pastor, White Wagtail and Greyheaded Yellow Wagtail)	Corn Earworms	Parasharya et al. 1996
No Reduction of Pest Insects in Wheat and Barley	Probably Due to Simplified Landscapes without Hedgerows, Treelines and Small Semi-Natural Habitat Patches	Italian Birds	Aphids	Tamburini et al. 2016
Reduced Pest Insects	Complex Landscapes Led to More Bird Abundance, Bird Species and Better Predation	EU Birds (mostly Skylarks, Yellowhammers and Whinchats)	Live Experimental Aphids	Winquist et al. 2011

II. Pollination Managed with Beneficial Birds

Beneficial Action by Birds	Effects of Habitat (Plants, Nest Boxes, Perches)	Beneficial Birds	Flowers	Reference
Feijoa				
Large Birds Increased Pollination in NZ But Not in California or Japan Possibly Due to No Nearby Habitat	Esp Near Shelterbelts in NZ	NZ Blackbirds and Mynahs	Large Birds Deposited Sufficient Pollent for-Fruit Development	Stewart & Craig 1989
Loquat				
Increased Pollination Which Resulted in Better Fruit Set		Japanese white-eyes and Light-vented Bulbuls	Birds Esp. Important in Late Winter	Fang et al. 2012

III. Unwanted Plant Material (Weeds or Too Much Biomass) Managed with Beneficial Birds

Beneficial Action by Birds	Effects of Management in Different Crops	Beneficial Birds	Weeds/ Biomass	Reference
Various Crops				
Reduced Weed Seeds	Cranberry and Cotton Fields	Waterfowl	Various Weeds	Kirk et al. 1996.
Pastures				
Reduced Weeds by 32% Before Dispersal in One Permenant Pasture		EU Goldfinches	Invasive Weed: Nodding Thistle	Kelly & McCallum 1990
Rice				
78% Increase in Residue Decomposition in Untilled Fields	Winter Flooded Fields	Waterfowl	Rice Straw Biomass	Bird et al. 2000
Decreased Weeds by 52%	Winter Flooded Fields	Waterfowl	Grassy Weeds	van Groenigen et al. 2003
Wheat				
Reduced Weeds by 7% on Average		English Farm Birds	Wild Oats, Pigweed, Creeping Thistle	Holmes & Froud-Williams 2005

IV. Pest Rodents

Beneficial Action by Birds	Effects of Habitat (Nest Boxes and Perches) in Different Crops	Beneficial Birds	Pest Rodents	Reference
Nest Boxes				
Owls Consumed > 30K Rodents in 3 Years on 1 Vineyard; Average Cost of $0.34/Gopher Taken by Owls vs. $8.11/Gopher Trapped	Used Nest Boxes in Wine Grapes	Barn Owls	Botta's Pocket Gophers and CA Voles	Browning et al. 2016
Barn Owls Spent about 33% of their Time Foraging in Vineyards	Use of Next Boxes Increased in Wine Grapes with Uncultivated Habitats Nearby		Mainly CA Voles; Some Pocket Gophers and Mice, Insects and Other Birds	Castañeda 2018
Reduction of Rodents Using Nest Boxes Is Profitable According to Model	Used Nest Boxes in Various Farm Fields	Barn Owls	Rodents	Kan et al. 2014
Reduced Rodents; Gophers More Prevalent in Perennial Crops vs. Mice More in Annual Crops	Used Nest Boxes in Annual and Perennial Crops	Barn Owls	House Mice, W. Harvest Mice, W. Pocket Gophers and Voles	Kross et al. 2016
Annual Reduction of Rodents Possible When Pest Densities Do Not Exceed the Average, According to Model	Used Nest Boxes in Various Farm Fields	Barn Owls	W. Pocket Gophers and Voles	Kross & Baldwin 2016
Barn Owls More Likely to Use Boxes If Made of Wood, Facing North, High Off Ground and Near Grasslands	Used Nest Boxes in Wine Grapes	Barn Owls	Botta's Pocket Gophers and CA Voles	Wendt & Johnson 2017

Beneficial Action by Birds	Effects of Habitat (Nest Boxes and Perches) in Different Crops	Beneficial Birds	Pest Rodents	Reference
Perches				
Attracted Raptors But Did Not Reduce Voles	Used Perches in Apples	Red-tailed Hawks, N. Shrikes, Am. Kestrels, Saw-whet and Great Horned Owls	Voles	Askham 1990
Supported Raptors in Reducing Mice Population Growth and Mice Density	Used Perches in Soybeans; Best Success When 100 m Apart	Diurnal Raptors (White-tailed Kites and Nankeen Kestrels)	House Mice	Kay et al. 1994
Supported Raptors in Reducing Rodents; Costs Were 1/2 of Rodenticides	Used Perches in Wheat, Barley, Sugar Beets and Maize	Common Buzzards and Common Kestrels	Common Voles	Machar et al. 2017
Supported Raptors in Reducing Number of Reproductives Female Voles and Reducing Male's Home Ranges	Used Perches in Various Farm Fields	Am. Kestrels But Not Northeren Harriers	Gray-tailed Voles	Wolff et al. 1999
Raptors More Likely to Use Perches on Hilltops vs. Base of Hills and in Open Habitat vs. NearTrees	Used Perches in One Vineyard	Am. Kestrels, Barn Owls, Common Ravens, Great Horned Owls, Golden Eagles and Red-tailed Hawks	Undescribed	Wong & Kross 2018
Nest Boxes and Perches				
Avian Predators Lowered Rodent Numbers and Reduced Crop Damage	Used Nest Boxes and Perches in Various Farm Fields	Avian Predators	Rodents	Labuschagne et al. 2016
Supported Raptors in Reducing Rodents; Estimated Cost Savings of $7.5K/ Levee Mile	Used Perches on Levees Adjacent to Farm Fields	Red-tailed Hawks, Great Horned Owls and Barn Owls	Ground Squirrels and Gophers	Novak & Torfeh 2017

V. Pest Birds Managed with Beneficial Birds

Beneficial Action by Birds	Effects of Falconry & Habitat (Nest Boxes, Perches)	Beneficial Birds	Pest Birds	Reference
Falcons				
Reduced Nonnative Pest Birds by 78-83% & Grape Damage by 68%; Predicted Savings of US$234-326/ha for different grape varietals	Rare Falcons Were Introduced in Winegrapes	New Zealand Falcons	EU Starlings, Blackbirds, Song Thrushes and Australasian Silvereye	Kross et al. 2012
Nest Boxes				
Reduced Fruit-eating Birds Significantly Near Kestrel Boxes; Predicted Increase of $2.2-2.4K for State of Michigan Over Five Years	Used Kestrel Nest Boxes in Cherry Orchards	Am. Kestrels	Mainly Am. Robins, Cedar Waxwings, Common Grackles and Am. Crows	Shave et al. 2018; 2017; Lindell et al. 2018
Perches				
Reduced Pest Birds Resulting in Decreasing Grape Damage By >50%	Used Artificial Perches Near Wine Grapes	Australian Magpies But Not Raptors	EU Starlings, Blackbirds, Song Thrushes	Peisley et al. 2017

VI. Pest Birds Managed with Alternative Practices

Beneficial Action	Effects of Habitat	Effects of Management in Different Crops	Pest Birds	Reference
Bird Resistant Cultivars				
May Reduce Bird Damage	Esp. When Offering Birds' Preferred Alternative Foods	Use Bird Resistant Grain Cultivars	Grain-eating Birds	Bullard 1998
Reduced Pest Bird Damage		Used Bird Resistant Corn Cultivars	Red-winged Blackbirds	Dolbeer 1990
Reduced Pest Bird Damage		Some Peach Cultivars Were Less Attractive to Pest Birds	Fruit-eating NM Birds	Grasswitz & Fimbres 2013
Reduced Bird Damage		Used Different Sunflower Cultivars and Different Planting Dates	House Sparrows	Killi et al. 2004
Reduced Bird Damage		Used Bird Resistant Sunflower Cultivars	Oriental Greenfinch	Yasumoto et al. 2012

Beneficial Action	Effects of Habitat	Effects of Management in Different Crops	Pest Birds	Reference
Habitat Modification				
May Reduce Bird Damage	When Providing Alternative Food Source of Mustard Cover Crop that White-crowned Sparrows Like		White-crowned Sparrows	Brennan 2018 (per. com.)
Pest Bird Abundance Did Not Differ Between Crop Fields and Habitat	Riparian Strips of Trees and Shrubs Did Not Increase Breeding Habitat of Pest Birds		Red-winged Blackbirds	Deschenes et al. 2003
Reduced Success of Pest Bird Food-Searching Bouts	Esp. with Increased Sight Obstruction by Plants	Also, Esp. with Increased Bird-to-Bird Distances, and Recent Exposure to a Predator	EU Starlings	Devereux et al. 2006
Co-existed with Birds When Beneficial Before Corn Silking; Reduced Bird Presence When Pests After Silking	Provided Alternate Feeding Sites (Oat and Wheat Stubble or Delayed Ploughing of Early-harvested Sweet Corn When Later-maturing Corn Was Ripening)	Corn	Red-winged Blackbirds	Dolbeer 1990
Reduce Pest Birds	Supplemental Feeding with More of the Same Crop and Synchronizing Plantings with Those of Neighbors	Sunflowers	Red-winged and Yellow-headed Blackbirds and Common Grackles	Linz et al. 2011
Increased Pest Birds	Near Edges with Trees	Focus Winegrape Management Where Pest Bird Damage Occurs: Near Edges, Higher in Clusters, and at Specific Times During Ripening Season	EU Starlings	Somers & Morris 2002
No Increase in Birds Eating Seeds	Natural or Semi-natural Habitat Did Not Influence Consumption of Crops	Almonds and Sunflowers	32 Israeli Birds	Schäckermann et al. 2015
No Increase in Pest Birds	Hedgerows Did Not Attract Pest Birds		American Crows, and Red-winged and Brewer's Blackbirds	White et al. 2012
No Increase in Pest Birds	Esp Near Hedges	Flocking Birds Often Prefer Field Interiors	EU Starlings	Whitehead et al. 1995
Noise Deterrent Tactics				
Reduce Pest Birds		Propane Cannons	Red-winged and Yellow-headed Blackbirds, Common Grackles	Linz et al. 2011
Physical Barriers				
Reduced Pest Bird Damage		Placed Bags on Peaches	Fruit-eating NM Birds	Grasswitz & Fimbres 2013
Visual Scaring Techniques				
Reduced Bird Presence at Airport		Laser Beams	Gulls	Baxter 2007
Peer Research Is Lacking on What Strength of Lasers May Cause Long-term Harm to Birds		Laser Beams	All Types of Birds	Fernandez-Juricic 2018 (per. com.)
Reduced Pest Birds		Using Reflective Tape in Millet, Sunflower and Sweet Corn	Red-winged Blackbirds	Dolbeer 1986

Appendix B. Resources

All About Birds. Search for birds to learn more about their requirements, life history, ID information, location and songs. Cornell Lab of Ornithology.
https://www.allaboutbirds.org/
Audubon Birds & Climate Change Report. Shows current and predicted changes of birds' ranges.
http://climate.audubon.org/
Backyard Birding: Homes for Birds. Migratory Bird Species Program. US Fish and Wildlife Services.
https://www.fws.gov/birds/bird-enthusiasts/backyard/homes-for-birds.php#2a
COMET Planner. This is a carbon and greenhouse gas calculator for conservation practice planning and projects.
USDA NRCS and Colorado State University.
http://www.comet-planner.com/
eBird.org. Find out what birds are in your area and report birds you've seen. Audubon and Cornell Lab of Ornithology.
eBird.org
iNaturalist.org. Send a photo of a bird, other animal or plant so that it can be identified by fellow naturalists.
https://www.inaturalist.org/
Map of Life. Learn about the world's biodiversity and report species seen.
https://auth.mol.org/mobile
Merlin Bird App. Free cell phone app for bird identification. Cornell Lab of Ornithology.
http://merlin.allaboutbirds.org
Michigan State University IPM Program. Resources on natural enemy insects and online course on IPM.
www.canr.msu.edu/ipm/
Native Plant Database. Search for native plants in your region that support birds, and learn where you can buy them. Audubon.
www.audubon.org/native-plants
Natural Resources Conservation Service (NRCS). Provides technical and financial support to farmers interested in installing conservation practices for birds and other wildlife.
https://www.nrcs.usda.gov
NatureServe Explorer: An Online Encyclopedia of Life. Provides information on the conservation status of rare and endangered plants and animals by particular watersheds, and threatened ecosystems in the U.S. and Canada. NatureServe.
http://explorer.natureserve.org/index.htm

Relatives of this Chestnut-backed Chickadee (with insect) add more "dees" to the their chick-a-dee calls when they perceive increased danger from predators.

Nature Stewardship. Provides information on nest boxes and safe feeding of birds. Point Blue Conservation Science.
https://www.pointblue.org/tools-and-guidance/nature-stewardship/
Nest Watch. All About Bird Houses. Provides bird box plans and information on the requirements of cavity nesting birds. Cornell Lab of Ornithology.
https://nestwatch.org/learn/all-about-birdhouses/
Red List of Threatened Species and Key Biodiversity Areas, Biodiversity for Business. Gives information on the conservation status of rare and endangered plants and animals internationally. International Union for Conservation of Nature (IUCN).
https://portals.iucn.org/library/efiles/documents/2014-004.pdf
Standards for the Growing, Harvesting, Packing, and Holding of Produce for Human Consumption. Food and Drug Admin.
https://www.federalregister.gov/documents/2015/11/27/2015-28159/standards-for-the-growing-harvesting-packing-and-holding-of-produce-for-human-consumption
Tools for Farming and Ranching. Provides tools for improving wildlife-friendly practices on farms and ranches. Point Blue Conservation Science.
https://www.pointblue.org/tools-and-guidance/farming-ranching/
University of California IPM Program. Solve your pest problems with UC's best science.
www.ipm.ucanr.edu/

Appendix C. References

This publication presents information found in the review of over 600 scientific papers on the roles and effects of birds in agriculture. Selected references from that collection, including all the citations mentioned in this paper, can be found on Wild Farm Alliance's website: https://www.wildfarmalliance.org/bird_resource

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Swallow adult feeding young, 123RF

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Oak Titmouse, N. Uyeda

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How Birds' Diets, Foraging Strategies and Nesting Periods Affect the Farm
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Western Bluebird, N. Uyeda
Hedgerow in vineyard, J. Baumgartner
Oak tree with cavity, J. Baumgartner
Red-Shouldered Hawk, S. Earnshaw

How Best to Manage and Co-Exist with Pest Birds
Red-winged Blackbird, N. Uyeda
Woodleaf Farm, H. Atthowe

Learning about and satisfying the needs of beneficial birds that provide pest control services will bring more of them to your farm.

Riverhill Farm, S. Earnshaw
Great Horned Owl, A. Arcidiacono
Fresh Run Farm, J. Baumgartner

What Farmers Can Do to Make Farms More Bird-Friendly and Resilient
Snag, NRCS
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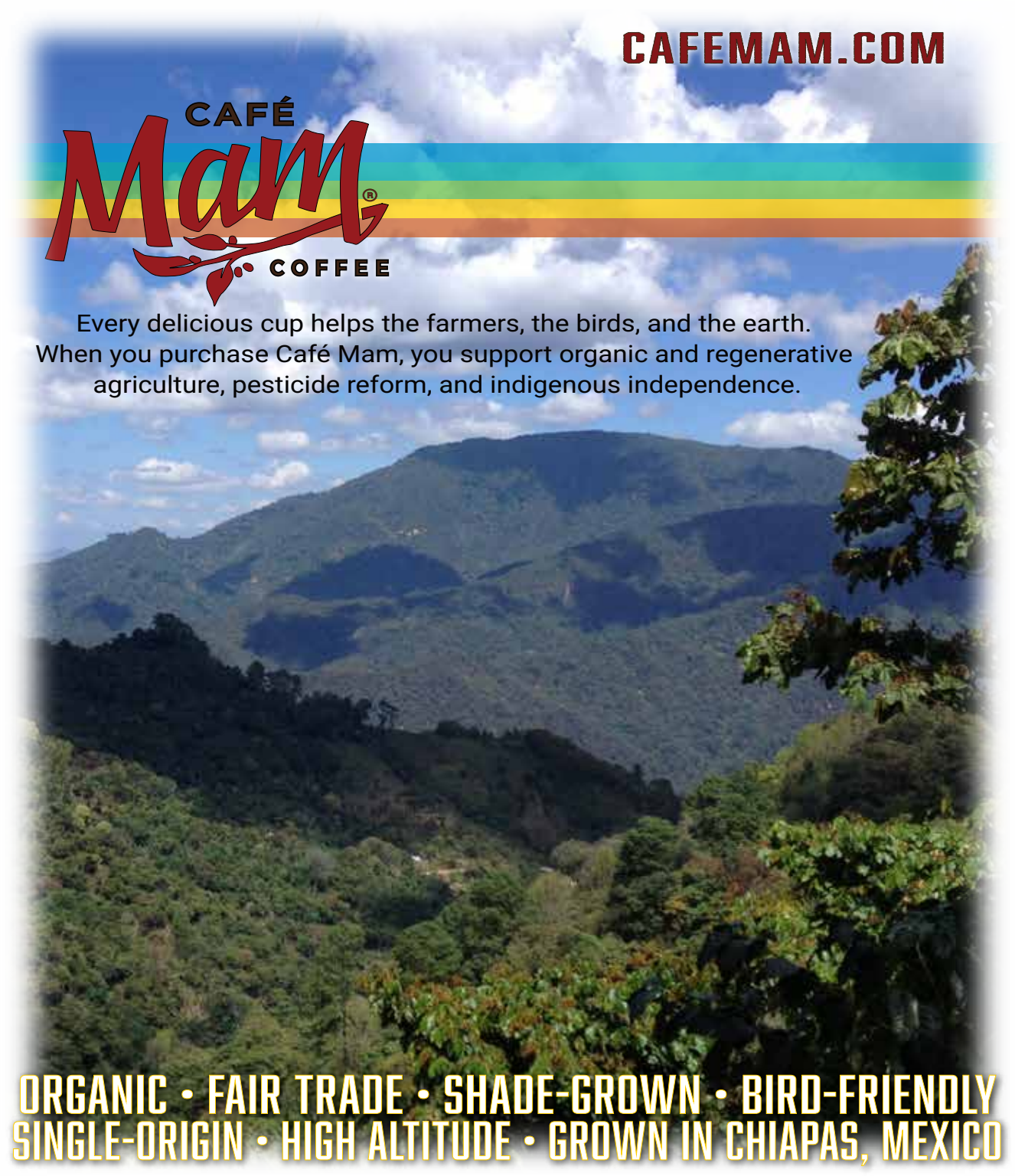
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