ABSTRACT: During a three-year study to assess the effectiveness of broadcast distress calls on American crows (*Corvus brachyrhynchos*) in almond orchards, we had the opportunity to identify other vertebrate pests, some of which are not well documented. We describe the damage caused by these "lesser-known" species and in selected cases estimate the crop loss from these other pests in eight orchards in the Central Valley of California. In addition to crows and California ground squirrels (*Spermophilus beecheyi*), we recorded the presence of seven other vertebrate pests: scrub jays (*Aphelocoma coerulescens*), yellow-billed magpies (*Pica nutalli*), common ravens (*Corvus corax*), deer mice (*Peromyscus* spp.), western gray squirrels (*Sciurus griseus*), wild pigs (*Sus scrofa*), and beaver (*Castor canadensis*). Jays and magpies were found in six of eight orchards and caused damage of at least $56/ha at one site. Jays and magpies showed a preference for the soft-shelled Nonpariel variety of almond and tended to damage trees throughout the orchards, as opposed to concentrated damage along the edges. Ravens and wild pigs were found only in two Fresno County orchards located next to wildlands of the Coast Range Mountains. We could not specifically identify nor value damage by ravens as they may have reacted to the broadcast crow distress calls and abandoned the treated orchard. Nut loss from pigs amounted to $17/ha. Pig damage could be identified from tracks, broken branches, and the smashed appearance of damage nuts. Deer mice were the most serious pest in the two Fresno County orchards with damage of up to $51/ha. Signs of deer mouse damage included small, fine incisor marks around the edge of the hole in the nut, small shavings from the hull and shell, and a concentration of damaged nuts in the crotch of the tree and around the base of the trunk. Tree squirrels were the most serious pest in one orchard with damage of $46/ha. Tree squirrel damage was concentrated on particular trees in the orchard and damaged nuts were opened in a characteristic manner. Beavers felled almond trees at one orchard located next to a watercourse. We speculate the presence and abundance of a vertebrate pest relate to local habitat conditions, geographic location, the adaptability of species, and the dynamic nature of wildlife populations.

KEY WORDS: almonds, *Aphelocoma coerulescens*, beaver, *Castor canadensis*, common raven, *Corvus corax*, damage, deer mouse, *Peromyscus* spp., *Pica nutalli*, *Sciurus griseus*, scrub jay, *Sus scrofa*, western gray squirrel, wild pig, yellow-billed magpie

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INTRODUCTION

Almonds are an important crop in California, ranking fourth among plant crops in the state with a production value of $1.1 billion in 1997 (California Farm Bureau Federation 1998). There has been an expansion in almond production with bearing acreage nearly doubling from 86,500 ha in 1973 to 162,000 ha in 1995 (Pradhan and Moulton 1996). The expansion of almond acreage into new areas, such as the western edge of the Central Valley adjacent to the Coast Range mountains, may have exposed almonds to new vertebrate pests. In turn, pest species and populations can be adaptable and dynamic, quite capable of utilizing new crops and food sources.

A number of vertebrate pests damage almonds. In particular, California ground squirrels (*Spermophilus beecheyi*) and American crows (*Corvus brachyryncos*) are well-known pests in almonds (Clark 1994; Marsh and Salmon 1996). During a study to assess the effectiveness of broadcast distress calls on American crows in almonds, we had the opportunity over a three-year period to observe other vertebrate pests. Our objectives in this paper are: 1) to identify these other pests, some of which are not well documented; 2) describe the damage they cause; and 3) in selected cases estimate the crop loss caused by these other pests.

STUDY AREAS

We studied vertebrate pests in eight almond orchards located in the Central Valley of California (Table 1). In 1997 and 1998 we used five orchards in the Sacramento Valley (northern part of the Central Valley). The Stiles, Dewey, and three orchards in Sutter County were small orchards (<8 ha), characteristic of many almond orchards in the region. All of these orchards were surrounded by crop lands. Alfalfa, hayfields, tomatoes, almonds, pistachios, and walnuts were common around Stiles and Dewey. Both of these orchards were bordered by a riparian zone that supported dense shrub and tree habitat. The three Sutter County orchards were the only mature almond orchards in a region dominated by peaches, prunes, and walnuts.

In 1999 we used larger orchards. The Conant orchard in Yuba County (Sacramento Valley) consisted of four blocks of almonds located adjacent to one another, totaling 32 ha. A riparian zone with a grove of oaks (*Quercus* spp.) bordered one block. Walnuts bordered all of the blocks. Rice, almonds, and pasture lands were located nearby.

We used two orchards in Fresno County, in the San Joaquin Valley (southern part of the Central Valley). The two orchards, Meyers 1 and 4, 22 ha and 40 ha in area,

Table 1. Location, area, number of trees, and age of study orchards in California.

Name	Location: Town	Location: County	Area (ha)	No. Trees	Age (yr.)
Dewey	Yolo	Yolo	2.4	321	19
Stiles	Davis	Yolo	6.5	977	29
Wada-Bailey	Yuba City	Sutter	2.7	690	17
Wada-Carlson	Yuba City	Sutter	5.0	705	>21
Wada-Oswald	Yuba City	Sutter	4.6	1,208	7
Conant	Wheatland	Yuba	32.2	5,112	16-18
Meyers 1	Firebaugh	Fresno	21.9	5,940	9
Meyers 4	Firebaugh	Fresno	39.8	10,835	9

respectively, were separated by a distance of approximately 10 km. Both orchards were located on the western edge of the intensively farmed valley floor. They directly bordered the wildlands of the Coast Range mountains. The extensive farmed lands near the orchards consisted of cotton, almonds, walnuts, grapes, and vegetable crops.

METHODS

From 1997 to 1999 we evaluated the efficacy of broadcast distress calls to reduce damage by crows. We observed several other species of vertebrate pests while collecting data on crows through bird counts and damage assessments in the orchards. We recorded our observations and the damage caused by these species.

Bird Counts

We counted birds in the morning on the study areas from mid-May through early September in 1997 and 1998. We drove around each orchard on a standard route, using binoculars as needed, and counted all crows, scrub jays (*Aphelocoma coerulescens*), and yellow-billed magpies (*Pica nutalli*) seen or heard. We varied the starting times for the counts and the order of the orchards from day to day. In 1999 bird counts were problematic at the Fresno and Yuba county sites. At the Yuba County sites heavy construction activities through much of the summer, including the laying of major pipeline and land-leveling activities for a new orchard, prevented access on a number of occasions. At the Fresno County sites bird counts as described above were not possible because of limited sight-lines due to the rolling terrain of the orchard and the "bushy" nature of the almond trees (a result of the particular pruning system used at this orchard with lower branches retained for more production).

Damage Assessment

We used a stratified random sampling design to assess damage within orchards (Crabb 1991). We divided each orchard into sampling blocks ranging from 40 to 230 trees/block depending on orchard size and layout. We assigned an identification number to each tree within a block and marked the corner trees for each block with plastic ribbon for reference. We selected at random one tree/block/week in each orchard for damage assessment. We divided the area ground under the tree canopy into eight equal sections or wedges, each equivalent to an arc of 45°, using the tree trunk as the center of the circle. We selected one wedge at random, and then counted damaged shells on the ground within the boundary of the selected wedge. Nuts damaged by birds typically had a hole in the side of the shell or half the shell missing along with the nut. We did not count whole nuts on the ground as bird damage due to the possibility of natural fall, even though birds will knock nuts from branches before feeding on the ground. We assigned damage caused by western gray squirrels (*Sciurus griseus*), deer mice (*Peromyscus* spp.), beaver (*Castor canadensis*), or wild pigs (*Sus scrofa*) according to the species-specific characteristics of the damaged hulls, shells, or other signs such as felled trees, bent or broken limbs, wallows, or tracks.

The first sampling measured damage that had occurred for an unknown time period prior to the first assessment. Thereafter, every week we selected new trees and wedges at random, swept the ground clean of all nuts in the selected wedge, and returned at approximately seven-day intervals to count damaged nuts. Damage could thus be assigned to periods of known length. Damage assessments began prior to treatment (broadcast of crow distress calls using Bird Gard™ units) and continued until the start of harvest.

following ...

$$nuts_o = [(nuts_d * 8)/tree_s] * tree_o$$

where:

$$nuts_{kg} = (nuts_o * 1.2gm) * 0.001\ kg/gm$$

$nuts_o$ = total number of nuts lost in the orchard.
$nuts_d$ = number of damaged nuts counted within the wedged-shaped sampling areas.
$tree_s$ = number of almond trees sampled.
$tree_o$ = total number of almond trees in the orchard.
$nuts_{kg}$ = weight of nuts lost in kg for the entire orchard.

We assumed that all nuts, if they had not been damaged, would have reached a weight of 1.2 gm/nut at harvest and had a value of $4.41/kg (W. Micke, pers. comm., Univ. Calif. Coop. Ext. Specialist). We refined the damage estimates by removing all non-bearing trees (e.g., recent transplants, diseased, or dead trees) from the $tree_o$ statistic.

RESULTS

We recorded the presence of seven other vertebrate pests in the orchards in addition to crows and California ground squirrels (Table 2).

from a tree and fly away, ... they may feed on the nut while in the orchard. A nut damaged by jays and magpies typically has a hole pecked in the center of the flat side of the hull and shell. The edge of the hole usually has a jagged, irregular outline as a result of the pecking. Individual damaged nuts could not be distinguished from those damaged by crows. Crows, however, will often knock many nuts to the ground and then descend to feed, leaving many damaged nuts under a tree. This feeding behavior results in an aggregated pattern of damage in an orchard as opposed to the random, less concentrated pattern of jay damage scattered throughout an orchard (Crabb 1991). In some cases it is possible to differentiate jay or magpie damage from crow damage on this basis.

Scrub jays and magpies were most abundant at Stiles and Dewey in 1997 and 1998 (Table 3). Although in some cases it appeared that jay or magpie numbers decreased during the treatment period (broadcast of distress calls), the change in numbers was not consistent at all sites nor did we observe any apparent reaction by jays or magpies to the crow distress calls.

Table 2. Vertebrate pests present in Central Valley study orchards in California, 1997 to 1999.

	American Crow	Common Raven	Yellow-billed Magpie	Scrub Jay	Calif. Ground Squirrel	Deer Mouse	Tree Squirrel	Beaver	Wild Pig
Stiles	X		X	X	X			X	
Dewey	X		X	X	X				
Wada-Carlson	X		X	X	X				
Wada-Bailey	X		X	X	X				
Wada-Oswald	X		X	X					
Conant	X		X	X		X	X		
Meyers 1	X	X			X	X			X
Meyers 4	X	X				X			X

Table 3. Average number of scrub jays (ScJA) and yellow-billed magpies (YbMa) counted in six almond orchards in California from 1997 to 1999. Numbers in parentheses represent the standard error, n is the number of bird counts conducted.

			Orchard					
Year	Species	Period[a]	Dewey	Stiles	Carlson	Bailey	Oswald	Conant
1997	ScJa	1	1.2(0.3) n=9	3.5(1.0) n=6	0.5(0.3) n=4	1.0(1.0) n=3	0.8(0.6) n=5	-
		2	2.2(0.8) n=14	5.4(0.8) n=24	0.6(0.2) n=23	0.9(0.3) n=28	0.5(0.2) n=25	-
	YbMa	1	9.0(2.1) n=9	13.8(4.1) n=6	0.2(0.2) n=4	0(-) n=3	3.4(2.2) n=5	-
		2	4.8(1.5) n=14	3.0(0.5) n=24	1.5(0.4) n=23	0.9(0.2) n=28	1.8(0.5) n=25	-
1998	ScJa	1	2.7(0.3) n=14	6.5(0.9) n=26	1.0(0.3) n=15	0.8(0.3) n=14	1.3(0.4) n=14	-
		2	2.0(0.4) n=22	3.8(0.6) n=32	0.4(0.2) n=37	0.4(0.1) n=59	1.2(0.3) n=32	-
	YbMa	1	2.1(0.7) n=14	5.0(1.4) n=26	0.3(0.2) n=15	0.8(0.4) n=14	1.6(0.8) n=14	-
		2	1.5(0.4) n=22	2.9(0.6) n=32	0.1(0.1) n=37	0.9(0.6) n=59	0.6(0.3) n=32	-
1999	ScJa	1	-	-	-	-	-	4.4(1.3) n=5
		2	-	-	-	-	-	4.6(1.8) n=8
	YbMa	1	-	-	-	-	-	1.4(0.5) n=5
		2	-	-	-	-	-	3.3(2.7) n=8

[a]Period 1=pretreatment period prior to broadcasts of crow distress calls, period 2=treatment when crow distress calls were broadcast.

Despite the problem of classifying bird damage by species, we were able to estimate the damage caused by jays and magpies at Stiles in 1998 (Table 4). During the pretreatment period low numbers of crows were observed in the orchard on 10 of 26 counts ($\bar{x}$=1.6, SE=1.0, range=0 to 25), thus damage during that period was attributed to all three species. However, after the start of treatment, crows virtually abandoned the orchard (Salmon et al. 1999). Crows were observed in the orchard on 2 of 32 counts ($\bar{x}$=0.2, SE=0.2, range=0 to 8), thus almost all damage during the treatment period was attributed to jays and magpies. During the treatment period damage by jays and magpies amounted to \$56.32/ha. Overall bird damage for the entire season amounted to \$77.50/ha, the majority of which is attributed to jays and magpies.

We examined damage by almond variety at Stiles (Table 5). The percentage of trees by variety that we sampled in the damage surveys did not differ (all tests of percentages use arcsine transformed data, X^2=0.81, 3 df, P=0.85) from the actual percentage of trees in the orchard as verified by tree counts. This result indicates our sampling technique was appropriate and accurately sampled the different varieties of almond trees. Assuming corvids had no preference or aversion to any variety of almonds, then damage to each variety should be equal to the percent occurrence of each variety in the orchard. When we examined the percentage of trees damaged by variety and compared it to the percentage of trees by variety in the orchard, we found no preference or aversion by variety (X^2=1.40, 3 df, P=0.70). This analysis, however, only discloses that certain trees have damage but does not indicate the degree of damage.

Table 4. Bird damage estimates in terms of nut and dollar loss for the Stiles almond orchard in northern California, June to August 1998.

Date	Nuts lost/ha (kg)	Loss/ha ($)	Loss/day ($)	Total Loss ($)
19 Jun	1.2	5.42	--	35.23
26 Jun	1.1	4.90	4.55	31.85
2 Jul	1.3	5.93	5.51	38.54
14 Jul	0.1	0.49	0.40	3.18
16 Jul	1.0	4.44	4.81	28.86
				Subtotal[a] 137.66
24 Jul	1.7	7.41	6.02	48.16
30 Jul	2.7	11.85	12.84	77.02
6 Aug	3.7	16.30	15.14	105.95
14 Aug	4.4	19.28	15.66	125.32
20 Aug[b]	--	--	--	--
28 Aug	0.3	1.48	1.20	9.62
				Subtotal[c] 366.07
Total	17.5	77.50	--	503.73

[a]Subtotal for the pretreatment period; damage attributed to crows, jays, and magpies.
[b]Plots not useable from 15-20 August due to mowing operations.
[c]Subtotal for the treatment period (broadcast of distress calls began on 16 July); damage attributed to jays and magpies only.

Table 5. Damage by corvids to almond trees by variety in the Stiles orchard in northern California, 1998.

No. trees sampled by variety	Percent of sampled trees[a]	Actual percent of trees in orchard[b]	No. of damaged trees	Percent of trees damaged by variety[c]	No. of damaged nuts	Percent of nuts damaged[d]
Nonpareil - 143	62.4	56.5	49	64.5	2248	82.6
Peerless - 37	16.2	23.2	10	13.2	192	7.1
Mission - 37	16.2	13.6	12	15.8	224	8.2
Merced - 12	5.2	6.7	5	6.6	56	2.1

[a](Number of trees sampled for each variety/total number of trees sampled at the given orchard)*100%; e.g., for Nonpareil at Stiles, (143/229)*100% = 62.4%.
[b]Based on counts by variety.
[c](Number of damaged trees for a given variety/total number of damaged trees for a given orchard)*100%; e.g., for Nonpareil at Stiles, (49/76)*100% = 64.5%.
[d](Number of damaged nuts for a given variety/total number of damaged nuts for a given orchard)*100%; e.g., for Nonpareil at Stiles, (2248/2720)*100% = 82.6%.

Subsequently, further examination based on the proportion of damaged nuts by variety showed one variety suffered more damage than expected and one variety had less damage than expected. At Stiles the Nonpareil trees (a soft-shelled variety) were damaged to a greater degree than expected (X^2=8.70, 3 df, P=0.034). Conversely, the Peerless trees (a hard-shelled variety) had less nut loss than expected. All other varieties were damaged to the degree expected.

Our field observations and subsequent tests showed that crows frequently used the edges of the orchards, causing more damage along the edges than in the interior portions of the orchards (Salmon et al. 1999). To test Crabb's (1991) assertion that there was no "edge effect" in the pattern of jay damage, we compared the damage on trees in the first three rows around the outer edges of Stiles to damage from the rest of the trees in the inner portions (Table 6). First, the percentage of trees in the outer edge and inner core that we sampled in the damage surveys did not differ (Fisher exact test, P=0.08) from the actual percentage of trees in the outer edges and inner cores as verified by tree counts. As noted above for damage by variety, this result indicates our sampling technique accurately sampled the trees in the two zones. Again, we assumed that if the jays and magpies used each zone equally, then damage (as measured by the proportion of damaged nuts) in each zone should be equal to the proportion of trees in each zone. At Stiles we found no difference (Fisher exact test, P=0.51) in the proportions between the two zones, indicating no concentration of damage in the outer rows of the orchard.

Common Ravens

We observed common ravens (*Corvus corax*) only in the Meyers orchards and only during the pretreatment period. Ravens may have responded to the broadcast crow distress calls and avoided the treated orchard (Meyers 4). We observed low numbers of ravens in the general area throughout the summer. Ravens are considered pests to nut crops; 33% of the pistachio growers in the southern San Joaquin Valley responding to a questionnaire reported damage by ravens (Salmon et al. 1986). However, we could not confirm any damage by ravens nor assign specific damage signs to ravens. We never observed ravens in the Sacramento Valley orchards as that region is not occupied range.

Deer Mice

Deer mice were present in the Meyers and Conant orchards. Deer mice typically chewed into the center of the flat side of almond shell, creating an oblong hole running from the proximal end to the distal end of the nut. Small, fine incisor marks around the edge of the hole and small shavings from the hull and shell were the primary signs of deer mouse damage. Deer mice can climb trees, as a result, damaged nuts and shavings were found in the crotch of the tree where the trunk divides to form limbs. We also found damaged nuts and shavings concentrated around the base of trees, especially if cover (e.g., almonds suckers) or burrows were present. We observed deer mouse sign infrequently at Conant; we judged deer mouse damage there as insignificant. However, deer mice were the most damaging species at Meyers 1 and 4. Damage ranged from \$19 to \$51/ha and totaled \$2,450 for both orchards (Tables 7 and 8).

Western Gray Squirrels

We observed western gray squirrels (a tree squirrel) only at Conant. Gray squirrels usually chew through and break up either the distal half or the proximal half of the nut, leaving the opposite, intact half of the hull and shell as the primary sign. Less often the tree squirrels sometimes chewed through the center of the flat side of the hull and shell, leaving a hole similar to that caused by birds. However, holes caused by squirrels may either have completely straight edges, or incisor marks may be present. Gray squirrels either knocked or clipped the nuts off trees, so many damaged and whole nuts were found scattered on the orchard floor under a tree. Often such damage was concentrated on groups of three or four trees in different locations in the orchard. Damaged nuts were also found near tree trunks, especially around suckers. Tree squirrels are know to strip bark from trees (Sullivan n.d.), but we did not observe any barking damage at Conant. Western gray squirrels caused the majority of damage at Conant. Total damage was valued at \$1,495 and \$46/ha (Table 9).

Wild Pigs

The grower informed us of the presence of wild pigs in Meyers 1 and 4 preceding the start of our research. We found pig tracks in the muddy areas along the drip lines within the orchards. The grower indicated that pigs have damaged drip lines in the past, but we did not observe any such damage. We did not realize that the pigs were damaging the almonds until late June 1999 when we discovered a new form of damage. The damaged shells and hulls appeared as though they had been smashed flat with a hammer. Shards of the hulls could be found around the damaged shells that remained. The pruning system used at the Meyers orchards retains branches low to the ground, leaving almonds within reach of pigs. In some cases the pigs bent and broke branches to obtain the nuts. On some limbs the bark had been shorn off, probably by the pig's tusks. Pig damage amounted to about \$17/ha each for both orchards and totaled \$1070 (Tables 10 and 11).

Beavers

Beaver damage occurred only at Stiles. In one incident, six trees were gnawed through and toppled during the course of a week. The damaged trees were adjacent to the creek and riparian zone on the south edge of the orchard. Beaver damage is obvious. The felled tree, pointed stump, wood chips around the stump, and drag marks to the water are easily identified. Beavers may remove small patches of bark from a tree to "sample" it (Jenkins 1978). We noted that strips of bark were removed from several almond trees during our damage assessments. The grower indicated that beavers destroyed 57 trees in 1997 and 1998. There was no damage in 1999 after federal trappers removed two adult beavers.

Location of Trees	No. of trees	No. of trees sampled	No. of damaged trees	No. of damaged nuts
Outer edge[a]	218 (22.3%)	81 (35.4%)	26 (32.1%)	760 (35.8%)
Inner core[b]	759 (77.7%)	148 (64.6%)	42 (28.4%)	1360 (64.2%)

[a]Trees in the first three rows around the outer edges of the orchard.
[b]All remaining trees not in the outer edge.

Table 7. Deer mice damage estimates in terms of nut and dollar loss for the Meyers 1 orchard in Fresno County, May to August 1999.

Date	Nuts lost/ha (kg)	Loss/ha ($)	Loss/day ($)	Total loss ($)
26 May	0	0	--	0
2 Jun	0	0	0	0
8 Jun	0.44	1.92	6.99	41.91
15 Jun	0	0	0	0
22 Jun	0	0	0	0
29 Jun	0	0	0	0
6 Jul	0	0	0	0
13 Jul	0	0	0	0
20 Jul	0.87	3.84	11.98	83.83
27 Jul	0	0	0	0
3 Aug	0.44	1.92	5.99	41.91
10 Aug	1.74	7.67	23.95	167.65
17 Aug	0.44	1.92	5.99	41.91
24 Aug	0.44	1.92	5.99	41.91
Total		19.19	-	419.12

Table 8. Deer mice damage estimates in terms of nut and dollar loss for the Meyers 4 orchard in Fresno County, May to August 1999.

Date	Nuts lost/ha (kg)	Loss/ha ($)	Loss/day ($)	Total loss ($)
26 May	0	0	--	0
2 Jun	0.87	3.84	21.84	152.90
8 Jun	0.44	1.92	12.74	76.45
15 Jun	1.16	5.12	29.12	203.87
22 Jun	1.45	6.40	36.41	254.84
29 Jun	0.44	1.92	10.92	76.45
6 Jul	0.73	3.20	18.20	127.42
13 Jul	0.29	1.28	7.28	50.97
20 Jul	1.16	5.12	29.12	203.87
27 Jul	0.29	1.28	7.28	50.97
3 Aug	0.62	2.71	15.42	107.93
10 Aug	2.32	10.24	58.25	407.74
17 Aug	0.58	2.56	14.56	101.94
24 Aug	1.23	5.42	30.84	215.86
Total		51.01	-	2031.21

Date	Nuts lost/ha (kg)	Loss/ha ($)	Loss/day ($)	Total loss ($)
17 May	1.39	6.15	--	198.06
24 May	2.98	13.16	60.60	424.18
31 May	0.28	1.22	5.62	39.37
7 Jun	0.26	1.13	5.21	36.44
14 Jun	0.12	0.51	2.37	16.56
21 Jun	1.12	4.95	22.80	159.57
28 Jun	1.67	7.36	33.87	237.06
5 Jul	0.06	0.26	1.19	8.31
12 Jul	0.58	2.57	11.81	82.69
19 Jul	0.10	0.46	2.11	14.78
26 Jul	0.03	0.13	0.59	4.14
2 Aug	0.67	2.97	13.65	95.58
9 Aug	0.26	1.15	5.28	36.98
16 Aug	0.27	1.20	5.55	38.83
23 Aug	0.18	0.77	3.55	24.87
30 Aug	0.55	2.41	11.09	77.62
Total		46.40	--	1495.04

Table 10. Wild pig damage estimates in terms of nut and dollar loss for the Meyers 1 orchard in Fresno County, June to August 1999.

Date	Nuts lost/ha (kg)	Loss/ha ($)	Loss/day ($)	Total loss ($)
29 Jun	0	0	--	0
6 Jul	0	0	0	0
13 Jul	0	0	0	0
20 Jul	0	0	0	0
27 Jul	0	0	0	0
3 Aug	0.44	1.92	5.99	41.91
10 Aug	3.48	15.35	47.90	335.30
17 Aug	0	0	0	0
24 Aug	0	0	0	0
Total		17.27	--	377.21

Table 11. Wild pig damage estimates in terms of nut and dollar loss for the Meyers 4 orchard in Fresno County, June to August 1999.

Date	Nuts lost/ha (kg)	Loss/ha ($)	Loss/day ($)	Total loss ($)
29 Jun	0.73	3.20	--	127.42
6 Jul	0	0	0	0
13 Jul	1.60	7.04	40.05	280.32
20 Jul	1.16	5.12	29.12	203.87
27 Jul	0	0	0	0
3 Aug	0	0	0	0
10 Aug	0	0	0	0
17 Aug	0	0	0	0
24 Aug	0.46	2.03	11.56	80.95
Total		17.39	--	692.56

given orchard may [...] local habitat conditions may favor some species. For example, local habitat bordering Stiles served as a travelway. The water course bordering Stiles served as a travelway and exposed the orchard to damage by beavers. The favorable habitat of tall trees and dense shrub-growth in the riparian zones next to Stiles and Dewey probably contributed to the high numbers of jays and magpies compared to the other orchards. We frequently observed jays and magpies flying back and forth from the riparian areas to the orchards. Similarly, the presence of a nearby heavily-wooded watercourse and numerous walnut orchards may have provided gray squirrels with routes to reach and use the Conant orchard.

Geographic location may determine the presence or absence of a pest. The six orchards in northern California had no ravens or wild pigs because they were located outside of the occupied ranges of the two species. On the other hand, the establishment of the Meyers orchards on the edge of wildlands represented an expansion of agriculture into a natural habitat already occupied by ravens, deer mice, and wild pigs.

Adaptability and the dynamic nature of wildlife populations may also play a role in the presence and abundance of a species. With the establishment of the Meyers orchards, ravens, deer mice, and wild pigs adapted to the favorable conditions (e.g., new food and water sources) provided by the new almond orchards. The wild pig provides an excellent example. Wild pig populations have increased dramatically in California. Wild pigs increased their range from a relatively few coastal areas in the 1960s to 49 of California's 58 counties by 1996 (Waithman et al. 1999). Wild pig populations in the central Coast Range near the Fresno County orchards are among the highest in the state (Waithman et al. 1999). The high population numbers and range expansion have in part been attributed to high reproductive output, enhanced adaptive abilities resulting from interbreeding with Eurasian wild boar, and increased forage availability associated with agricultural development. Irrigated agricultural fields provide abundant forage, and in the case of the Meyer orchards with drip-line irrigation, moist sites for wallowing. During the hot, dry season pigs frequent cool, moist sites to wallow at night (Baber and Coblentz 1986). Due to the need for heavy cover in response to high daytime temperatures in the summer, wild pigs may travel up to 10 km daily between daytime bedding sites and nighttime foraging sites (Barrett 1978). Pigs have not been observed by the grower in the orchards during the day. The grower reported an absence of cover where pigs could rest during the day for a distance of at least 1.6 km west from the orchards into the mountains. This suggests pigs were traveling at least 3.2 km each night between daytime cover and the orchards, which is well within reported travel distances.

Some of the species we observed are not widely known as pests in almonds or the extent of damage they cause has not been documented. Most almond growers may be aware of jays and magpies because they are loud and conspicuous, but it is unlikely that many are aware the grower mentioned deer [...] clipped buds or blossoms in the spring, requiring application of anticoagulant bait. Deer mice were the most serious pest during the summer, with damage amounting to \$51/ha at Meyers 4. Again, this estimate is conservative because it does not account for nuts eaten in the crotch of a tree or taken into burrows. Western gray squirrels caused the majority of the damage at Conant, amounting to \$46/ha despite an ongoing squirrel control program. Tree squirrel damage in almonds has not been widely reported, having only been reported to us from only a few orchards in Fresno County (M. Freeman, pers. comm., Univ. Calif. Farm Advisor). At this time tree squirrels appear to be a local, but potentially serious problem for almond growers.

MANAGEMENT IMPLICATIONS

The presence of several "lesser-known" vertebrate pests in our study orchards points to several considerations for growers and managers:

1. Species usually considered as minor pests (e.g., deer mice, tree squirrels) may cause significant economic loss.
2. Wildlife species can be quite adaptable, capable of altering or developing new behaviors to take advantage of new food or water sources, and other situations.
3. Wildlife populations are dynamic; numbers can increase rapidly, geographic range can expand.
4. Managers must have the ability to identify damage caused by a variety of species, and need to be alert to potential new pests.
5. Managers need to have a plan or the knowledge of how to cope with any potential pest.

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