A SURVEY OF BIRDS AND PESTICIDE USE IN ORCHARDS IN THE SOUTH OKANAGAN/SIMILKAMEEN REGION OF BRITISH COLUMBIA, 1991

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ABSTRACT

We studied birds' use of fruit orchards in relation to pesticide applications in the South Okanagan and Similkameen Valleys, British Columbia, from May to August 1991. Preliminary assessment was made of the suitability of American Robin (*Turdus migratorius*) and California Quail (*Callipepla californica*) for monitoring effects of pesticides on birds. Abundance, diversity, activities, and breeding success of birds using orchard habitats were investigated using point counts and nest searches (all species), and radio-tracking (California Quail only).

A total of 54 bird species were observed in the orchards, including 10 species found nesting and 25 species seen feeding. The most abundant species were American Robin, European Starling (*Sturnus vulgaris*), American Goldfinch (*Carduelis tristis*), California Quail, Brown-headed Cowbird (*Molothrus ater*), and Mourning Dove (*Zenaida macroura*). American Robins were the most common and conspicuous nesting species in the orchards. California Quail frequently foraged in orchards in May and June, and used non-orchard habitats more often in July and August. They tended to roost and nest in areas adjacent to, and often a few metres from, orchards.

Interviews with orchard managers showed that conventionally managed apple orchards received an average of 10 chemical applications over five months, including an average of four treatments with organophosphate insecticides. At least four of the insecticides used are highly toxic to birds.

We concluded that:

(1) Both American Robin and California Quail may be useful for monitoring exposure and effects of pesticides on birds. Nestling robins are present in orchards during the spray

period and thus are potentially exposed to pesticides, while quail frequently feed in orchards during the spray season. Further studies are required to determine exposure to anticholinesterase insecticides by measuring blood cholinesterase activity and analyzing for pesticide metabolites in feces. More detailed observations should also be made immediately following pesticide applications, to determine whether those species are actually ingesting food potentially contaminated with pesticide residues.

(2) Diazinon, dimethoate (Cygon), azinphos-methyl (Guthion), and phosmet (Imidan) are pesticides of concern, due to their toxicity to birds and the frequency of their use in the study area.

RÉSUMÉ

Nous avons étudié la présence oiseaux dans les vergers du sud de la vallée de l'Okanagan et dans la vallée de la Similkameen (Colombie-Britannique), du mois de mai au mois d'août 1991, en relation avec l'application de pewticides. On a d'abord évalué si le merle d'Amérique (*Turdus migratorius*) et le colin de Californie (*Callipepla californica*) convenaient à l'observation de l'effet des pesticides sur les oiseaux. On a examiné l'abondance, la diversité, les activités et le nombre de nouveaux-nés des oiseaux nichés dans les vergers au moyen de comptages en un point et d'inspections des nids (toutes les espèces), et par radio-repérage (colin de Californie seulement).

Au total, on a observé 54 espèces d'oiseaux dans les vergers, dont 10 espèces qui y nichaient et 25 espèces qui s'y nourrissaient. Le merle d'Amerique, l'étourneau sansonnet (*Sturnus vulgaris*), le chardonneret jaune (*Carduelis tristis*), le colin de Californie, le vacher à tête brune (*Molothrus ater*) et la tourterelle triste (*Zenaida macroura*) étaient les espèces les plus nombreuses. Le merle d'Amérique était l'espèce la plus commune et la plus visible à nicher dans les vergers. On a fréquemment observé le colin de Californie qui picorait dans les vergers en mai et juin, et qui nichait en dehors des vergers surtout en juillet et août. Il avait tendance à se percher et à nicher dans des endroits adjacents aux vergers, et souvent à quelques mètres des vergers.

Des enquêtes auprès des gérants de vergers ont révélé que dans les vergers entretenus de faÇon conventionnelle, on procédait à 10 applications de produits chimiques sur une période de cinq mois, dont une moyenne de quatre traitements avec des insecticides organosphosporés. Au moins quatre des insecticides utilisés étaient hautement toxiques pour les oiseaux.

Nous avons conclu que :

(1) La merle d'Amérique et le colin de Californie peuvent être utiles pour évaluer l'exposition aux pesticides et l'effet de ces pesticides sur les oiseaux. D'une part, les oisillons des merles sont dans les vergers pendant la période d'arrosage; ils sont donc exposés aux pesticides. D'autre part, le colin se nourrit fréquemment dans les vergers pendant la saison d'arrosage. Il faudra faire des études plus approfondies pour déterminer l'exposition aux insecticides anticholinestérasiques, en mesurant l'activité de la cholinestérase globulaire et en faisant une analyse des métabolites des pesticides dans les excréments. Il faudrait également faire des observations plus détaillées immédiatement après les applications de pesticides, pour déterminer si ces espèces mangent réellement des aliments qui peuvent être contaminés par des résidus de pesticides.

(2) On se pose surtout des questions au sujet du diazinon, de la diméthoate (Cygon), de l'azinphos-méthyle (Guthion) et du phosmet (Imidan), en raison de leur toxicité pour les oiseaux et de la fréquence de leur utilisation dan la région étudiée.

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ACKNOWLEDGEMENTS

Alan Preston and Margaret Harris provided technical support throughout this study, and carried out much of the field work. Thanks are also due to the 28 growers in Penticton, Oliver, and Cawston who allowed us access to their orchards for bird surveys and kindly provided information on pesticide use. BC Ministry of Agriculture and Ministry of Environment (Wildlife Branch) in Oliver and Penticton provided helpful comments during the field work. Pam Whitehead assisted with drafting and Shelagh Bucknell with word processing. Andre Breault and Pierre Mineau reviewed an earlier draft of this report. This project was partially funded by Environment Canada's Pestfund.

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1. GENERAL INTRODUCTION

The Okanagan/Similkameen area produces 99.4% by weight of the tree fruits grown in British Columbia (BCMAFF, 1989). It also supports a remarkably diverse bird community, due to its location at the confluence of several ecoregions (Cannings *et al.*, 1987). According to 1981 data (Kerr *et al.* 1985), orchards cover 16% of the valley bottom, which has largely been cleared for grazing and other agriculture (45%) or is in built-up and urban uses (15%). Thus, orchard land may be an important habitat for birds of the valley bottom that use trees for nesting, foraging, or cover.

Most orchards are treated heavily with pesticides. Highly persistent organochlorine insecticides such as DDT, which were commonly used in the 1960's and 70's, have largely been replaced by organophosphates. In general the organophosphates are less persistent but have higher acute toxicities than organochlorine insecticides. While organophosphates generally do not bioaccumulate, the impact of both acute and chronic wildlife exposure requires further study.

To date in the Okanagan Valley there have been five recorded bird kills associated with ingestion of organophosphate pesticides. The insecticide diazinon was found in the digestive tracts of birds killed in four of these incidents, which involved a total of 28 Canada Geese. The remaining incident involved 100 Canada Geese and was attributed to the insecticide parathion, which is still registered but no longer recommended for use on tree fruits in British Columbia (BCMAF, 1991). Deaths of smaller birds and sub-lethal effects are less likely to be detected.

In this study we determined the species at risk and investigated the hazards of pesticides to birds inhabiting orchards in the South Okanagan and Similkameen Valleys.

2. BIRD SURVEYS

2.1 OBJECTIVES

1. To determine the species composition of the bird community in South Okanagan fruit orchards;
2. to determine which of these species feed in orchards;
3. to analyze patterns of abundance relative to orchard characteristics.

2.2 METHODS

We selected 44 orchard blocks as survey sites in orchard areas of the South Okanagan and Similkameen Valleys during March and April, 1991 (Fig. 1). An orchard block was defined as a uniform-age plot of one type of fruit tree. A block was considered suitable if it was at least 50m by 50m in area and the grower was present to permit access to the property. We chose 15 blocks in Penticton, 14 in Oliver, and 15 in Cawston. Seven of the Cawston orchard blocks were managed 'organically' (i.e. chemical pesticides had not been used for at least five years); all others were managed 'conventionally', using chemical pesticides. Of the 44 orchard blocks selected for count points there were 28 apple, five peach, four cherry, four pear, two prune, and one apricot block (Table 1).

Birds were surveyed using point counts. During each count, an observer stood at a marked point 25m in from the two edges at the corner of an orchard block, and recorded all birds seen or heard in any direction. For each bird observed, distance from the observer was estimated and recorded as either 0-25m, 25-50m, 50-100m, or greater than 100m. Each point

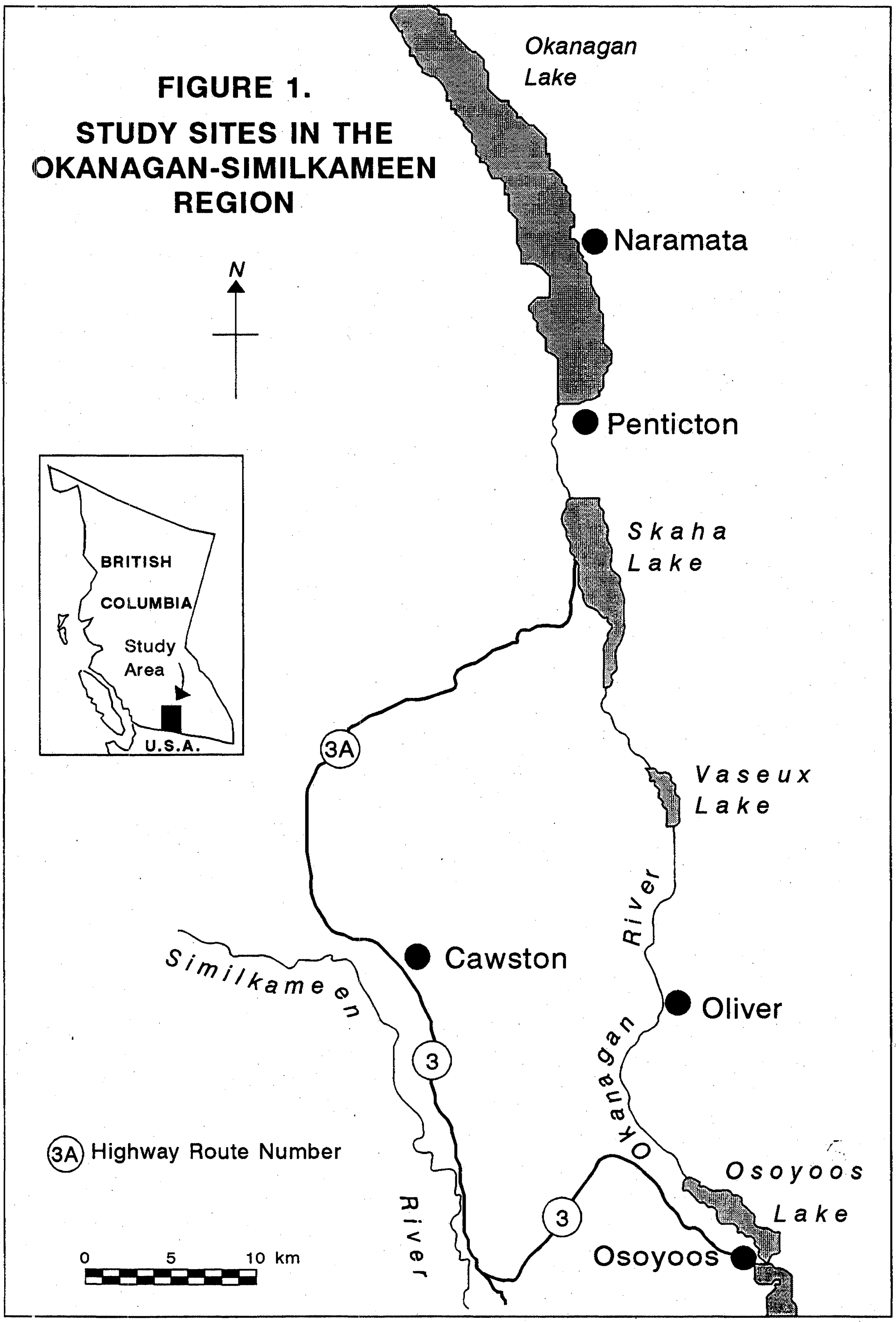


FIGURE 1.
STUDY SITES IN THE
OKANAGAN-SIMILKAMEEN
REGION
N
Okanagan
Lake
Naramata
Penticton
Skaha
Lake
Vaseux
Lake
Okanagan River
Oliver
Osoyoos
Lake
Osoyoos
Cawston
Similkameen
River
3A
3
3
BRITISH
COLUMBIA
Study
Area
U.S.A.
3A Highway Route Number
0 5 10 km

Table 1. Number of orchard blocks surveyed, by town and fruit type.

		TOWN		
Fruit	Total	Cawston	Oliver	Penticton
Apple	28 (5)[1]	11 (5)	7	10
Peach	5		4	1
Pear	4 (1)	2 (1)		2
Cherry	4 (1)	2 (1)	1	1
Prune	2		2	
Apricot	1			1
Total	44 (7)	15 (7)	14	15

1. Number of blocks managed without the use of chemical pesticides (ie. organic blocks) given in parentheses. Organic blocks are also included in the overall totals.

count lasted 12 minutes, starting when the observer arrived at the marked point. Because of the small size of many orchard blocks, only the birds observed within 25m were necessarily in the block being surveyed (Fig. 2). Birds observed within 25m and within 50m of the point were considered separately in the present analyses. Sex and age were recorded when known, and behaviours such as foraging, singing, calling, and flying were noted. Birds flying over a count point without landing were not included in the present analysis, except for aerial foragers such as swallows.

One point was surveyed per orchard block (N=44), five times between 1 May and 15 July 1991, once during each of five 15-day intervals. Counts were conducted during the first three hours after sunrise. Points were divided into three routes per town, and each route was surveyed by a single observer on a given morning. The assignment of the three observers to routes, the direction in which routes were followed, and the order in which the towns were surveyed within a 15-day period were all chosen at random.

After completion of all point counts, one observer measured the following habitat/visibility variables at all orchard blocks: height of orchard trees, spacing of rows and trees within rows, proportion of sky visible from the count point, and distance along the ground visible from the count point, both along rows and across them. At the beginning of each point count, the following weather variables were recorded: temperature, Beaufort wind speed, wind direction, cloud cover, and precipitation.

We obtained information on pesticide use from orchard managers, using a written questionnaire combined with telephone or personal interviews (detailed results are presented in

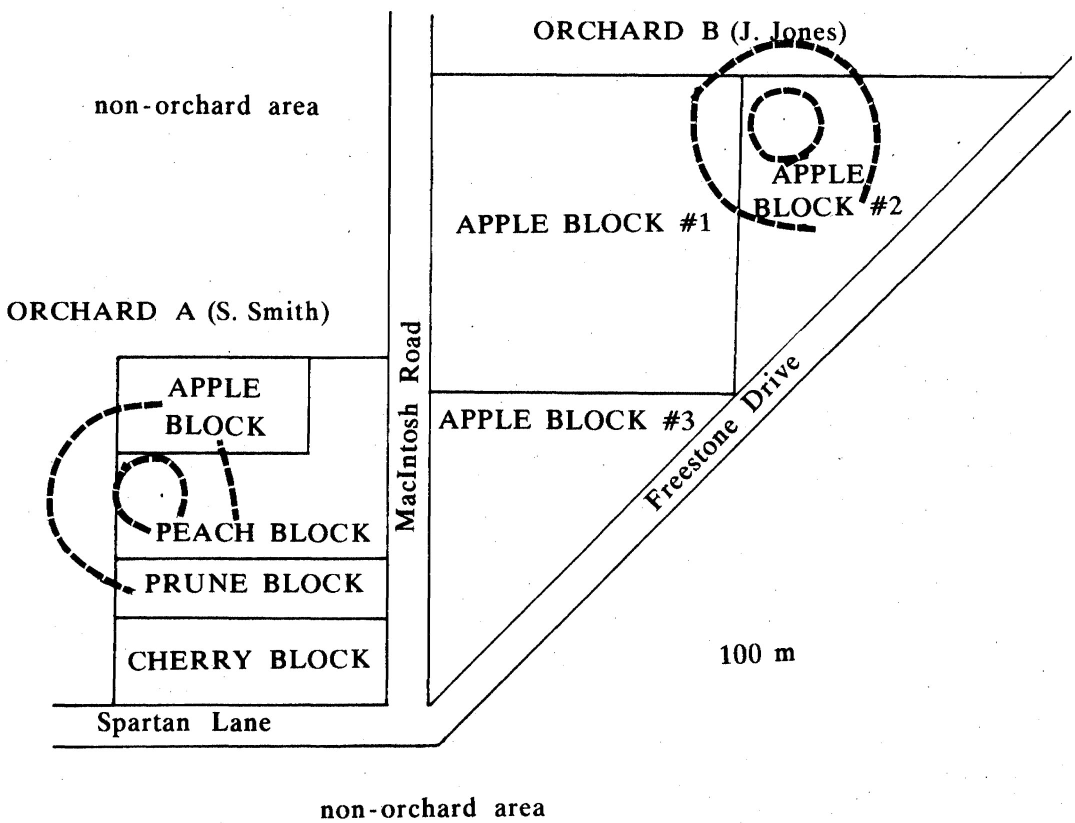


Fig. 2 Point Count locations in a typical orchard area, showing 25m radius around the count points.

Section V). Based on this survey, we recorded the number of applications of pest control materials (i.e. the number of times the grower sprayed the orchard), and number of applications of organophosphate or organochlorine insecticides during the survey period. The total number of applications was considered to represent the amount of human disturbance in an orchard, while the number of organophosphate and organochlorine insecticide applications was used as a measure of the quantity of chemicals toxic to birds.

2.2.1 Data Analysis

Total Richness for an orchard type was defined as the total number of bird species observed there, at all points combined. Richness for each count point was the total number of species observed there on all five counts combined. **Mean Richness** for an orchard type was the mean of the Richness values for the count points. Abundance for a count point was the maximum number of individuals of a particular species observed during any of the five counts. Overall Abundance for a count point was the sum of all species' abundances for that point. **Mean Abundance** for an orchard type was the mean of the Abundances at each count point, for a particular species. **Mean Overall Abundance** for an orchard type was the mean of the Overall Abundance values for the count points.

In order to assess the adequacy of the number of points sampled for each orchard type, count points were placed in random order and cumulative total richness was calculated and plotted against number of point counts.

We performed parametric one-way analyses of variance (ANOVA) of richness and abundances by orchard type. The orchard types compared in this way were apples versus soft fruit (peach, cherry, pear, prune, apricot), and conventional versus organic, and the three towns were compared. We also performed one-way ANOVAs of habitat and weather by orchard type.

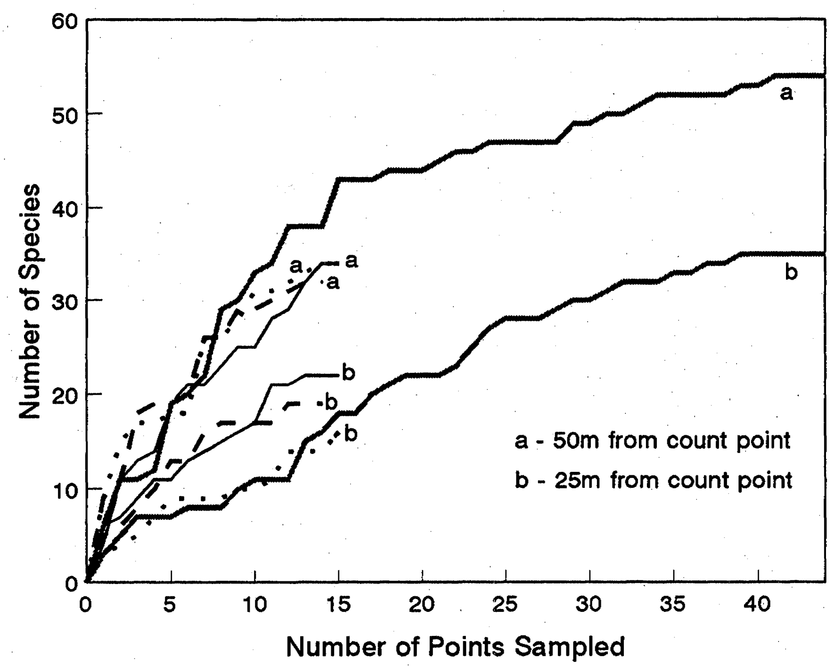
In order to reveal any effects that pesticide applications had on bird numbers, beyond the effects of orchard type and other habitat variables and visibility of birds, multiple regressions were performed on richness and abundances by town, fruit type, tree spacing, ground visibility, sky visibility, overall number of pesticide applications, and number of applications of OP's and OC's. The significance of the last variable was used as an indication of whether or not these highly toxic insecticides affected numbers of birds.

In order to detect preferences of feeding birds for different fruit orchards, their distribution among fruit types was compared to the numbers of blocks sampled of each fruit, using a Chi-square test.

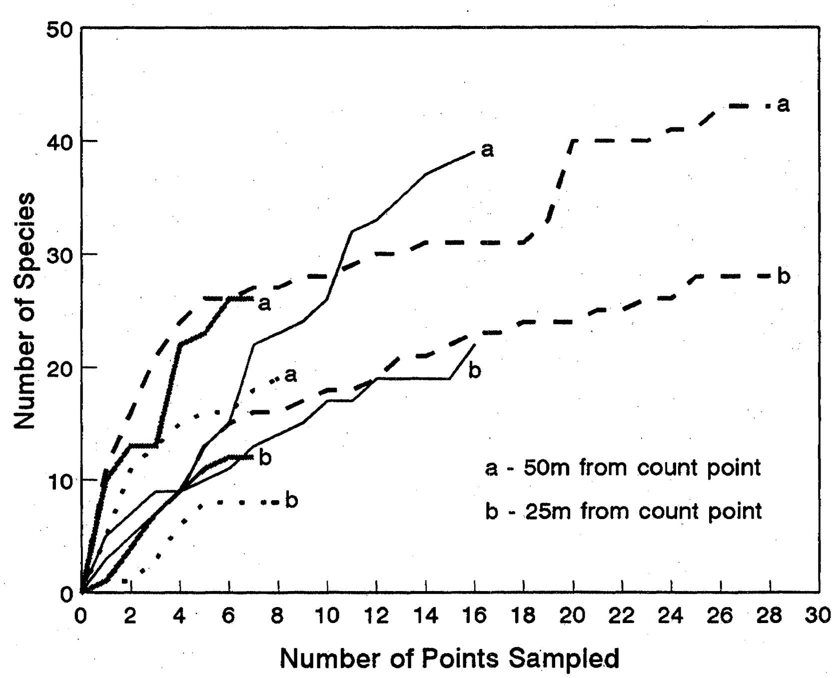
2.3 RESULTS

The graph of cumulative richness values versus number of orchard blocks sampled (Fig. 3) showed that sample sizes were sufficient (ie. that almost all species had been detected) for apple orchards (N=28) and for orchards overall (N=44) but insufficient for soft fruit orchards (N=16), each of the three towns (N=14, N=15, N=15), and the two management types in Cawston (N=7, N=8).

Thirty-five species were observed within 25m of the marked points, and 54 species were observed within 50m (Table 2). Within 25m, the most frequently encountered species were American Robin, which occurred at 57% of the points surveyed, European Starling (25% of



i) Overall · · · · Cawston — — Oliver ——— Penticton



ii) Organic · · · · Conventional — — Apple ——— Soft Fruit

Figure 3. Cumulative species richness, a) overall and for each area; b) by fruit types and management types.

Table 2. Frequency of occurence (percent of blocks sampled) of birds observed on point counts.

	Within 25m of Count Point								Within 50m of Count Point							
		Town[1]			Fruit[2]		Method[3]			Town			Fruit		Method	
	t[4]	C	O	P	A	S	C	O	t	C	O	P	A	S	C	O
Number of blocks	44	15	14	15	28	16	8	7	44	15	14	15	28	16	8	7
Total Richness	35	16	19	22	28	22	8	12	54	34	32	34	43	39	19	26
American Robin	57	67	57	47	54	62	75	57	80	93	71	73	82	75	100	86
European Starling	25	27	21	27	21	31	38	14	57	73	36	60	54	62	75	71
Tree Swallow	23		7	60	18	31			34	13	14	73	29	44		29
American Goldfinch	20	20	29	13	21	19	25	14	41	47	50	27	39	44	50	43
Brown-headed Cowbird	14	20	7	13	14	12	25	14	48	53	57	33	46	50	50	57
Mourning Dove	11		14	20	14	6			27	20	21	40	36	12	25	14
House Finch	9		14	13	4	19			57	47	71	53	57	56	50	43
California Quail	9	7	14	7	7	12	12		39	40	36	40	32	50	62	14
Chipping Sparrow	9	7	21		14			14	20	7	50	7	29	6		14
White-crowned Sparrow	7	13		7	11			29	16	27	7	13	21	6	25	29
Rough-winged Swallow	7			20	7	6			14	7		33	11	19	12	
Savannah Sparrow	7	13	7		7	6	25		11	13	14	7	11	12	25	
Northern Flicker	4		14		4	6			41	33	57	33	21	75	25	43
Black-billed Magpie	4		7	7	4	6			23	7	7	53	25	19		14
Cedar Waxwing	4	7	7		4	6		14	20	13	36	13	21	19		29
Northern Oriole	4	7		7	7			14	18	27	7	20	21	12	12	43
Barn Swallow	4	7		7	7			14	16	20		27	21	6		43
Western Meadowlark	4	13			7		25		16	40	7		21	6	38	43
Bank Swallow	4			13	4	6			14		21	20	7	25		
Black-capped Chickadee	4		7	7	4	6			9		7	20	7	12		
Calliope Hummingbird	4	7		7	7			14	7	7	7	7	7	6		14
Ring-necked Pheasant	2			7		6			11			33	11	12		
Yellow-rumped Warbler	2		7			6			9	13	14		7	12		29
Rufous Hummingbird	2	7			4			14	4	7	7		4	6		14
Red-winged Blackbird	2			7	4				4	7		7	7			14
House Sparrow	2	7			4			14	4	7	7		7			14
Western Kingbird	2		7		4				4	7	7		7		12	

Table 2. (Cont...) Frequency of occurence (percent of blocks sampled) of birds observed on point counts.

	Within 25m of Count Point								Within 50m of Count Point							
		Town[1]			Fruit[2]		Method[3]			Town			Fruit		Method	
	t[4]	C	O	P	A	S	C	O	t	C	O	P	A	S	C	O
Mountain Chickadee	2			7		6			2			7		6		
Nashville Warbler	2		7			6			2		7			6		
Western Wood-Pewee	2		7			6			2		7			6		
Vaux's Swift	2			7	4				2			7	4			
Vesper Sparrow	2	7			4		12		2	7			4		12	
Least Flycatcher	2			7	4				2			7	4			
Hammond's Flycatcher	2		7			6			2		7			6		
Song Sparrow	2			7		6			2			7		6		
Evening Grosbeak									7	7	7	7	7	6	12	
American Kestrel									4			13	4	6		
Western Bluebird									4			13	4	6		
House Wren									4	7		7	7			14
American Crow									4	7		7	4	6	12	
Lewis' Woodpecker									2	7			4			14
Killdeer									2	7			4		12	
Ring-necked Dove									2	7			4		12	
Hairy Woodpecker									2			7		6		
Lazuli Bunting									2		7			6		
Eastern Kingbird									2	7			4			14
Steller's Jay									2		7			6		
Common Nighthawk									2			7	4			
Pine Siskin									2		7			6		
Say's Phoebe									2	7			4			14
Yellow Warbler									2	7			4			14
Ruby-crowned Kinglet									2		7			6		
Cassin's Finch									2		7			6		
Brewer's Blackbird									2			7	4			

1. C=Cawston, O=Oliver, P=Penticton. 2. A=Apple, S=Soft Fruit. 3. C=Conventional, O=Organic. 4. t=overall total

of points), American Goldfinch (20%), Brown-headed Cowbird (14%), and Mourning Dove (11%). Tree Swallows (Tachycineta bicolor) were seen feeding above 23% of the points.

Within 50m of the marked points, the most frequent species were American Robin (80% of points), European Starling and House Finch (Carpodacus mexicanus) (57%), Brown-headed Cowbird (48%), American Goldfinch and Northern Flicker (Colaptes auratus) (41%), California Quail (39%), Mourning Dove (27%), Black-billed Magpie (Pica pica) (23%), and Chipping Sparrow (Spizella passerina) and Cedar Waxwing (Bombycilla cedrorum) (20%). Tree Swallows were seen feeding above 34% of points.

In general, the species most frequently encountered within 25m of count points were also the most abundant species, except that California Quail were more abundant but occurred at fewer points than Cowbirds and Mourning Doves (Table 3). The same pattern is apparent within 50 m of count points (Table 4), where California Quail were more abundant but less frequently encountered than Starling, Goldfinch, Cowbird, and Flicker.

Species Richness, Overall Abundance, and Abundance of most species were similar in all three towns. The only exceptions (ANOVA, $p < .05$) were swallows (all species summed), which were most abundant in Penticton (within 25 and 50m of points), and Robins, which were most abundant in Cawston (within 50m of points).

There were no significant differences in abundance between fruit types or farm management methods at the 95% probability level. However, Northern Flickers were more abundant within 50m of count points in soft fruit blocks than apple blocks ($p < 0.1$), and swallows were more abundant within 50m of points in organic than conventionally managed orchards in Cawston ($p < 0.1$).

Table 3. Species richness, species diversity, and abundance(±se) of birds observed within 25m of count points.

		TOWN			FRUIT		METHOD	
	TOTAL	Cawston	Oliver	Penticton	Apple	Soft Fruit	Conventional	Organic
Number of Blocks	44	15	14	15	28	16	8	7
TOTAL RICHNESS	35	16	19	22	28	22	8	12
H' DIVERSITY	2.9	2.3	2.7	2.3	2.8	2.6	1.8	2.2
MEAN RICHNESS	2.7±.24	2.3±.30	2.6±.46	3.1±.48	2.6±.29	2.8±.44	2.4±.38	2.3±.52
MEAN OVERALL ABUNDANCE	4.7±.58	**3.5±.49**	**4.1±.79**	**6.4±1.4**	4.7±.77	4.6±.88	3.6±.62	3.3±.81
MEAN ABUNDANCES								
American Robin	.82±.13	1.1±.27	.86±.23	.53±.16	.75±.16	.94±.23	1.4±.42	.71±.29
European Starling	.50±.18	.53±.26	.21±.11	.73±.47	.36±.15	.75±.44	.75±.75	.29±.29
American Goldfinch	.27±.09	.20±.11	.43±.20	.20±.14	.29±.11	.25±.14	.25±.16	.14±.14
California Quail	.22±.13	.13±.13	.50±.37	.07±.07	.25±.19	.19±.14	.25±.25	
Brown-headed Cowbird	.18±.08	.20±.11	.07±.07	.27±.18	.18±.09	.19±.14		
Mourning Dove	.14±.06		.21±.16	.20±.11	.18±.09	.06±.06		
Swallow Spp.	1.2±.47	**.07±.07**	**.14±.14**	**3.3±1.2**	1.4±.71	.81±.36		.14±.14

Table 4. Species richness, species diversity, and abundance (± se) of birds observed within 50m of count points.

		TOWN			FRUIT		METHOD	
	TOTAL	Cawston	Oliver	Penticton	Apple	Soft Fruit	Conventional	Organic
Number of Blocks	44	15	14	15	28	16	8	7
TOTAL RICHNESS	54	34	32	34	43	39	19	26
H' DIVERSITY	3.2	2.9	2.9	2.9	3.1	3.0	2.4	2.9
MEAN RICHNESS	7.2±.49	6.9±.98	6.8±.84	7.9±.73	7.1±.63	7.4±.79	6.2±.94	7.7±1.8
MEAN OVERALL ABUNDANCE	14±1.4	13±2.6	12±1.7	18±2.7	15±2.0	13±1.9	13±4.2	14±3.4
MEAN ABUNDANCES								
American Robin	1.6±.17	**2.2±.24**	**1.4±.29**	**1.1±.29**	1.6±.20	1.6±.32	2.5±.33	1.9±.34
House Finch	1.4±.37	1.0±.53	1.9±.61	1.4±.79	1.5±.53	1.2±.43	1.4±.96	.57±.30
California Quail	1.3±.37	1.2±.56	1.1±.46	1.7±.86	1.2±.44	1.6±.69	1.2±.45	1.1±1.1
European Starling	1.1±.25	1.6±.52	.50±.20	1.1±.45	1.0±.30	1.2±.43	1.1±.35	2.1±1.0
American Goldfinch	.75±.19	.53±.16	1.1±.38	.60±.40	.54±.15	1.1±.45	.62±.26	.43±.20
Brown-headed Cowbird	.68±.13	.87±.26	.64±.17	.53±.24	.71±.17	.62±.20	.75±.31	1.0±.44
Northern Flicker	.59±.16	.40±.16	.64±.17	.73±.41	.39±.22	.94±.17	.25±.16	.57±.30
Black-billed Magpie	.41±.13	.13±.13	.07±.07	1.0±.29	.50±.18	.25±.14		.29±.29
Mourning Dove	.41±.11	.20±.11	.36±.22	.67±.23	.50±.15	.25±.17	.25±.16	.14±.14
Cedar Waxwing	.34±.12	.40±.29	.43±.17	.20±.14	.39±.17	.25±.14		.86±.60
Chipping Sparrow	.27±.09	.13±.13	.64±.20	.07±.07	.39±.13	.06±.06		.29±.29
Tree Swallow	1.5±.44	.13±.09	.29±.19	3.9±1.0	1.7±.66	1.1±.39		.29±.18
Swallow Spp.	2.5±.73	**.40±.16**	**.86±.47**	**6.1±1.8**	2.8±1.1	2.0±.58	.12±.12	.71±.29

Several differences were detected in weather and habitat characteristics among orchards in different towns, and between apple and soft fruit orchards (Table 5). For example, Cawston was significantly windier than the other towns ($p<.01$), and soft fruit trees were taller and more widely spaced than apple trees ($p<.05$).

Multiple regressions did not reveal any significant negative effects of organophosphate and organochlorine insecticides on numbers of birds, after the effects of other habitat variables were accounted for.

A total of 299 observations were made of birds feeding in orchards during point counts; these involved 25 species (Table 6). Most (160) observations were of aerial foragers such as swallows, feeding on insects above the trees. Of the 139 other observations, most were of ground foragers, while a few were of insectivorous birds feeding in the trees. Birds were not observed feeding on fruit during point counts, which ended in mid-July; however on five occasions House Finches and Cassin's Finches (Carpodacus cassinii) were observed feeding on blossoms. In addition to the 25 species observed feeding in orchards during point counts, four other species were observed incidentally. These included European Starlings and Cedar Waxwings feeding on cherries later in the season.

Observations of aerial feeding were non-uniformly distributed among the different types of fruit trees (Chi-square test, $p=.05$, $df=5$), being disproportionately high over cherry blocks. Observations of feeding California Quail were disproportionately high in apple blocks compared to soft fruit (Chi-square test, $p=.03$, $df=1$).

Table 5. Habitat and weather variables with significant differences between towns or fruit types (ANOVA, $p < 0.05$). Towns and fruit types are listed in order of high to low mean values of the variable.

Variable	Town	Fruit
Tree Height		Soft Fruit Apples
Ground Visibility	Cawston Oliver Penticton	
Row Spacing		Soft Fruit Apples
Tree Spacing		Soft Fruit Apples
Temperature	Oliver Penticton Cawston	
Wind Speed	Cawston Penticton Oliver	
Number of Sprays		Apples Soft Fruit
Number of Toxic Insecticides	Penticton Oliver Cawston	Apples Soft Fruit

Table 6. Number of sightings of birds feeding in orchards during point counts.

SPECIES	FRUIT						
	Total	Apple	Peach	Pear	Cherry	Prune	Apricot
Number of Blocks	44	28	5	4	4	2	1
GROUND AND TREE FORAGERS							
White-crowned Sparrow	31	31					
American Robin	30	18	2	2	7	1	
California Quail	25	22	2	1			
European Starling	17	9		7	1		
Savannah Sparrow	6	5	1				
Mourning Dove	5	5					
Northern Flicker	3	1				2	
American Goldfinch	3	2		1			
Cassin's Finch	3		3				
Brown-headed Cowbird	2	1		1			
House Finch	2				1	1	
Nashville Warbler	2		2				
Chipping Sparrow	2	2					
Black-capped Chickadee	2					2	
American Crow	2					2	
Killdeer	1	1					
Mountain Chickadee	1				1		
Calliope Hummingbird	1	1					
Hammond's Flycatcher	1				1		
TOTAL	139	98	10	12	11	8	
AERIAL FORAGERS							
Tree Swallow	97	66	5	10	9		7
Bank Swallow	33	8	6		17		2
Rough-winged Swallow	14	10		1	2		1
Barn Swallow	11	11					
Common Nighthawk	4	4					
Vaux's Swift	1	1					
TOTAL	160	100	11	11	28		10
OVERALL TOTAL	299	198	21	23	39	8	10

2.4 DISCUSSION

The abundance values presented here are relative, and should be used only to compare orchard types in this study. Most studies that use point counts measure relative densities of breeding birds, whereas our purpose was to determine which species use orchards during the spraying season, regardless of whether they were in migration or breeding. Our abundance values for species such as American Robin, which begin breeding early, represent breeding birds; but overall abundance and species richness values include such species as White-crowned Sparrow, which feeds in orchards during migration in May but does not breed in Okanagan orchards.

From the graphs of cumulative species richness by number of points sampled (Fig. 3), it appears that 25 to 30 count points per orchard type would be adequate to detect most species. The three towns, as well as soft fruit blocks and organic orchard blocks, were inadequately sampled in this study. This suggests that larger sample sizes may have revealed patterns of abundance that were not detected in this study, especially for less common species, and differences between organic and conventional orchards in Cawston, for which sample sizes were quite low.

In this study, the number of points that could be set up was limited by the time required to locate blocks of sufficient size and a variety of ages and fruit types, and to locate and contact landowners to obtain permission to use each orchard block. The number of points that could be sampled on a given morning was limited by the extreme patchiness of orchards. More blocks could have been sampled, for example, if it had been possible to walk transects of count points through large contiguous orchard areas. This may be possible in a few locations where quiet roads could be used as transect lines, but such an approach might result in an over-representation of roadside birds; and landowners would still have to be contacted individually for information on pesticide applications.

Difficulties encountered during point counts included the constant strong wind in Cawston, which probably reduced the number of birds heard, especially beyond 25m from count points. Throughout the study area, calm dry mornings were the favoured time for spraying orchards, and this conflicted with point counts. Some point counts had to be postponed to an alternate morning if spraying was occurring in the block to be surveyed, and the noise of spraying even several blocks away affected the observer's ability to hear birds. While wind speed was recorded at the beginning of each count because it might affect the audibility of birds, sprayer noise was not recorded. Sprayer noise, and highway noise where applicable, should be noted in any future bird surveys in Okanagan orchards.

In spite of small sample sizes, some patterns of abundance were detected, and general species composition in the orchards was documented. The species most frequently encountered were birds with broad habitat requirements which have adapted to habitats with a strong human influence. Of the six most common species in the orchards surveyed, two (European Starling and California Quail) were introduced (i.e. non-native) and one (Brown-headed Cowbird) was a brood parasite, and all six were common birds of gardens and residential areas (Cannings *et al.*, 1987).

One cavity-nesting species, the Northern Flicker, was more common in soft fruit than apple orchards. Trees in soft fruit blocks were significantly taller and more widely spaced, suggesting that the trees tend to be older than apple trees. The current trend toward dwarf apple trees will reduce the availability of nest sites for flickers and other cavity nesters.

The only indication that pesticides might have had a negative effect on numbers of birds was that foraging swallows were non-significantly more abundant over organic than conventionally-managed orchards in Cawston. Otherwise, neither management type nor the number of applications of highly toxic insecticides or of pesticides overall showed a negative relationship between pesticides and birds.

This study, however, does not show that pesticides do not affect birds in Okanagan orchards. Only seven organic orchard blocks were sampled, and this was shown to be inadequate. Species diversity appeared higher in organic than conventional orchards, and a higher sample size might show this difference to be significant. Further analysis might show that variables not considered in the present analysis, such as the type of habitat surrounding an orchard block and the amount of human disturbance in and around the block, affected richness and abundance and masked the effects of pesticides.

Many birds were seen feeding in orchards. It would be interesting to analyze the seasonal distribution of these observations in relation to pesticide applications, as well as determine the type of food eaten, in order to assess whether birds are attracted to dying insects after an insecticide spray, or whether they avoid orchard blocks that have recently been sprayed. A number of studies have shown that pheasants, Quail and other birds can discriminate and avoid foods contaminated with pesticides (Bennett & Prince, 1981; Kononen *et al.*, 1987; Bennett, 1989).

2.5 SUMMARY

Fifty-four species of birds were found during point-count surveys of orchards. The most abundant species were American Robin, European Starling, American Goldfinch, California Quail, Brown-headed Cowbird, House Finch, Mourning Dove, and Northern Flicker. Swallows were frequently observed feeding over orchards, and were most abundant in Penticton, over organic orchards in Cawston, and over cherry orchards throughout the study area. Northern Flickers were more abundant in soft fruit than apple orchards; soft fruit trees were larger and more widely spaced than apple trees. California Quail were seen feeding in apple orchards more often than in soft fruit orchards. The number of applications of organophosphate and organochlorine insecticides did not appear to affect numbers of birds; however, the number of points surveyed may not have been adequate to detect such effects. Further, variables such as surrounding habitat type and frequency of human disturbance, which were not measured in this study, may have masked effects of pesticides on birds.

3. NESTING BIRDS

3.1 OBJECTIVES

1. to determine which bird species nest in orchards in the South Okanagan/Similkameen Region
2. to compare productivity of nesting birds in organic versus conventional orchards

3.2 METHODS

Nests were found using row-by-row searches in orchards with point-count blocks. Additional nests were found incidentally in other orchards and also in non-orchard habitats. Visits were made every few days to determine nesting success. One egg was removed from some nests, usually during the laying period, for organochlorine analysis. We refer to these as 'manipulated' nests; results of organochlorine analysis are reported elsewhere (Elliott *et al.*, in prep). Eggs were usually removed during the laying period.

T-tests were used to compare productivity (four measures tested separately: clutch size, number of eggs hatched, number of young fledged and the proportion of eggs that produced fledged young) of organic versus conventional orchards and apple versus soft fruit orchards. Productivity was then compared between manipulated and unmanipulated nests, also using t-tests.

3.3 RESULTS

Sixty-seven nests of ten species were found in orchards, including seven tree-nesting and three cavity-nesting species (Table 7). No ground-nests were found, though orchardists reported nests of California Quail, Ring-necked Pheasant, and Killdeer from previous years. The most

Table 7. Number of nests found in each type of fruit tree.

		Orchard						Upland
Species	Total	Apple	Pear	Cherry	Peach	Apricot	Other	
American Robin	34	19	4	5		1	2	3
European Starling	17	3	6	4		1	3	
Northern Flicker	4	1	1	2				
Cedar Waxwing	3	1	1		1			
House Finch	3		1				2	
Black-billed Magpie	3	1					2	
American Goldfinch	2		1		1			
Mourning Dove	2	2						
Chipping Sparrow	1	1						
Mountain Chickadee	1	1						
Total	70	29	14	11	2	2	9	3

abundant nesting species found were American Robin (31 nests in orchards) and European Starling (17 nests in orchards).

A total of 34 Robin nests were monitored (including three non-orchard nests), and 10 of these had one egg removed for organochlorine analysis ('manipulated' nests). Robin eggs were present from 6 May to 1 June, and nestlings were seen from 12 May to 12 July. Mean clutch size was 3.4 (s.e.=0.2) eggs for the 18 Robin nests for which clutch size was determined and not manipulated. A mean of 2.0 (s.e.=.36) young were fledged from 22 unmanipulated nests (Table 8).

The 10 manipulated nests produced, on average, more eggs per nest (including the one removed) but fledged fewer young per nest than the 23 unmanipulated nests, though the differences were not significant (t-tests, $p>0.05$). Nests in conventionally managed orchards produced non-significantly more young than nests in organic orchards, and orchard nests produced non-significantly more young than the three non-orchard nests. There were a few instances of nest abandonment and nestling death that roughly coincided with applications of pesticides. In one apple orchard, 3 nests with eggs were abandoned around the time of a gramoxone spray. In another apple orchard, 2 nestlings died at about one week of age, at least a week after a Guthion spray. In a pear orchard, some older nestlings died around the time of an application of detergent. None of these dead nestlings were consumed by predators or scavengers.

Table 8. Nesting success of American Robins in the study area.

Habitat Type	Clutch Size[1]	Number Hatched[2]	Number Fledged[3]	Nest Success[4]
Orchard	3.5±.21 (N=17)	2.3±.37 (N=21)	2.1±.36 (N=21)	68% (N=22)
Upland	3.0 (N=1)		0 (N=1)	0% (N=1)
Conventional	3.6±.18 (N=13)	2.5±.44 (N=15)	2.3±.45 (N=15)	67% (N=15)
Organic	3.0±.71 (N=4)	1.8±.70 (N=6)	1.7±.62 (N=6)	71% (N=7)
Apple	3.6±.18 (N=8)	2.2±.49 (N=12)	1.9±.50 (N=12)	62% (N=13)
Soft Fruit	3.2±.41 (N=8)	2.2±.62 (N=8)	2.1±.58 (N=8)	75% (N=8)
Overall Unmanipulated	3.4±.20 (N=18)	2.3±.37 (N=21)	2.0±.36 (N=22)	65% (N=23)
Manipulated[5]	3.8±.15 (N=9)	2.8±.20 (N=5)	1.1±.46 (N=10)	40% (N=10)

1. Clutch Size=number of eggs per nest.
2. Number Hatched=number of nestlings per nest.
3. Number Fledged=number of young which survived to fledging, per nest.
4. Nest Success=percent of nests which fledged at least one young.
5. Manipulated nests were nests which had had one egg removed for organochlorine analysis; Clutch size for these nests includes the removed egg; manipulated nests were not included in any other means presented in this table.

3.4 DISCUSSION

American Robin was the only species for which we were able to monitor enough nests for statistical analysis of productivity. Productivity of the second most commonly nesting species, European Starling, was not measured because nests were hidden in cavities. All other species were nesting at lower densities or their nests were more difficult to detect. Particularly scarce were ground-nesting species, which may avoid nesting in orchards with ground-level sprinklers. The transition from ditch irrigation to sprinklers in the Okanagan in the 1940's was accompanied by a marked decline in populations of Ring-necked Pheasants (Cannings *et al.*, 1987). Most of the orchards used in this study had ground-level sprinklers.

Robin nests that had one egg removed produced more eggs than unmanipulated nests, suggesting that Robins are able to compensate for a lost egg by increasing the number they lay. Only 40% of manipulated nests fledged young, while 65% of unmanipulated nests fledged young, suggesting that the removal of an egg reduced nesting success, possibly by causing adults to abandon nests.

Manipulation of clutch size reduced the number of nests available for productivity measurements and comparisons. For unmanipulated nests, the mean clutch size of 3.4 was similar to the mean of 3.6 reported by Cannings *et al.* (1987) for 177 Robin nests in the Okanagan Valley, a figure they say is higher than in other areas of the province. Percent of eggs that produced fledged young was also similar to the Cannings' data (59% of their 495 eggs in 141 nests, 61% of our 62 eggs in 18 nests).

Numbers of American Robins have increased in the Okanagan valley since the introduction of orchards and irrigation about a century ago (Cannings *et al.*, 1987). Densities of predators are likely to be low in orchards due to frequent human presence and destruction of certain predators such as large snakes. Depredation may be an important factor in Robin productivity; across all habitats, at least 66% of unsuccessful Robin nests in the Okanagan fail due to depredation (Cannings *et al.*, 1987).

No significant differences in productivity were found between orchard types, though productivity was slightly higher in conventional than organic orchards. In general it appears that South Okanagan Robins were not adversely affected by chemical pesticides. The nest abandonments and nestling deaths observed could not be linked to pesticide sprays with any certainty, since the precise timing of the deaths in relation to the sprays was not determined, and neither cholinesterase nor residue analysis was performed. It is, however, possible that individual Robins may be adversely affected by pesticides but this may be compensated for at the population level by the generally high productivity of Robins in irrigated orchard habitats. In addition, one nest in a conventionally-managed orchard had a nestling period of 19 days, which exceeds the range of 12-17 days found by Cannings *et al.* (1987) for 22 Okanagan nests. Length of the nestling period was not measured for other nests, as our visits were infrequent. There is evidence that organophosphate insecticides can reduce nestling growth rates, resulting in an extended nesting period and hence delayed fledging (Bairlein, 1991).

The apparent success of Robins in using orchard habitats for nesting indicates that robins are able to either avoid or to tolerate exposure to the highly toxic insecticidal sprays. If they are able to avoid exposure, perhaps by foraging in less-sprayed areas, then Robins may not be an appropriate species for monitoring pesticide effects on orchard birds. Johnson *et al.* (1976) reported that robins nesting in New York state orchards were observed to forage outside of the orchards. However, the extremely high levels of DDT-related compounds found in Okanagan robins (Elliott *et al.*, 1994) suggest that they are foraging within the orchards

If Robins are ingesting organophosphates but are able to tolerate high levels, then local populations of bird-eating raptors may be exposed to significant pesticide residues while consuming Robins. In the same manner, the extremely high levels of DDT-related compounds (up to 103 mg/kg DDE, 27 mg/kg DDT) would also adversely affect bird-eating raptors (Elliott *al.*, 1994). Exposure of bird-eating raptors could be examined by testing carcasses of sick and dead birds found in orchard areas.

Further studies should investigate whether adult Robins avoid heavily-sprayed areas while foraging, whether blood cholinesterase is reduced in nestlings in sprayed areas, whether nestling growth rates or fledging weights are reduced in orchards treated with highly toxic organophosphate insecticides such as diazinon, and whether exposure to organophosphates during nesting reduces survival of juveniles or adults over the following winter. If Robins are being exposed to organophosphate insecticides in Okanagan orchards, they may be a suitable species for monitoring pesticide effects since they are abundant and readily observable, their nests are easy to find, they are tolerant of human disturbance at the nest, and nestling growth rates are easily measured.

4. CALIFORNIA QUAIL STUDIES

4.1 OBJECTIVES

1. to examine the use of orchard habitats by California Quail
2. to assess the suitability of California Quail as a tool for monitoring effects of pesticides on orchard birds

4.2 METHODS

Trapping and colour-banding of Quail was initiated at two sites in the Penticton area but was discontinued almost immediately at one site due to insufficient personnel. The remaining site was at the edge of orchard country at the south end of Penticton, on the east side of Skaha Lake. The area in which Quail were tracked comprised a total of about 22 ha, of which 7 ha comprised of small orchards and about 15 ha of adjacent gullies, open ponderosa pine woods, and rocky ridges.

Quail were caught in "clover" traps baited with cracked corn, from 23 May to 15 June 1991. Each trap was made of three four-foot-long pieces of chicken wire arranged in the shape of a clover leaf, with narrow gaps between the three "leaves" for entrances. Metal stakes were used to anchor the chicken wire to the ground. A piece of fish net was draped over the top of the trap and clamped on to the chicken wire with clothes pegs. A hole about 10" wide was cut in one of the chicken wire sections at ground level, and a pouch of fish net was attached to the outside as a catch bag.

The traps were set up three weeks in advance without the fish net and with the entrances widened (about 8" wide) so birds could easily move in and out, and baited with cracked corn. When trapping began, we made the entrances narrower (about 3" wide) and attached the fish net. When a bird walked in to the trap, we approached and quickly covered the entire trap with a blanket to calm the bird. A section of the blanket was then lifted at the catch bag, and the bird would fly toward the light and get caught. The bird was easily extracted from the fish net catch bag.

Each bird was measured and outfitted with two coloured plastic bands on the right leg. Measurements taken were wing chord (flattened), tarsus, culmen (tip of bill to forward end of nostril), and length of head tuft (from beginning of feathering behind bill), all in mm.

Radio transmitters were attached between 30 May and 13 June using a nylon "poncho" made of raincoat cloth, following a design detailed by Amstrup (1980). The transmitter was sewn to the poncho with dental floss, and then covered with epoxy. When a Quail was captured, the poncho was pulled on over its head, and hung around the neck so that the antenna pointed up and back, and the transmitter was on the upper side of the poncho, in front of the bird's neck.

Quail were tracked on foot from 30 May to 26 August 1991, using a portable receiver and one "H" antenna. During tracking, an effort was made to locate all radio-tagged Quail and record location, habitat, and behaviour. Seasonal patterns of orchard use were examined by marking locations on a 1:5000 scale aerial photograph of the area, measuring the distance to the nearest orchard (distance=0m if the bird was in an orchard), and comparing for each bird separately those distances in June versus July. The measurements of distance from orchards were imprecise (but not biased) because the aerial photograph was not received until after the tracking was completed, and locations were determined from written descriptions in field notes.

4.3 RESULTS

Twenty Quail were banded at two locations in Penticton (Table 9). Six Quail were fitted with radio transmitters (Table 10). Transmitters were removed by four of the six birds, one to 50 days after fitting. None of the radio-tagged birds was preyed upon. Four nests were found, including three nests of two radio-collared females (Table 11). Seven broods were observed with marked birds (Table 12). Twelve observations were made of Quail feeding on identifiable foods (Table 13). Five radio-tagged Quail were located a total of 102 times, with a minimum of 14 observations per bird.

The Quail appeared to spend long periods of time roosting in brush adjacent to orchards during the day, making feeding forays into or along the edges of orchards. Most spent nights in communal roosts, also adjacent to orchards. They appeared to feed mostly in orchards in May and June, and move into non-irrigated habitats in July. Average distance from orchards in June ranged from 10m to 60m for five individuals, while in July it ranged from 35m to 285m for four individuals. One individual observed seven times in May was 2m from orchards on average. Each of four individuals tracked in both June and July was seen closer to orchards in June than July, and for two of these birds the difference was statistically significant (Mann Whitney U test, $p < 0.02$). The other two birds were each seen only five times in July.

Table 9. Colour coding and morphological measurements of California Quail captured in 1991.

BANDS[1]	DATE	TIME	LOCATION	SEX	WING (mm)	TARSUS (mm)	CULMEN (mm)	TUFT (mm)
B/W	23/5	1515	A	M	120	39	9	51
O/B	25/5	1500	B	M	113	38	8	49
W/P	25/5	0745	B	F	113	39	8	33
R/W	30/5	1110	A	M	118	37	8.5	49
Y/R	30/5	1110	A	M	115	38	8	49
O/O	30/5	1200	A	F	110	37	7.5	35
P/B	30/5	1615	A	M	119	40	8.5	48
W/R	03/6	1530	A	F	108	35		43
W/Y	03/6	1640	A	M	114	38	8	50
W/B	03/6	1719	A	M	115	39	8	50
W/B	04/6	1453	A	M	110	38	8	45
W/W	04/6	1453	A	F	110	38	6	38
B/Y	04/6	1613	A	M	120	40	8	46
B/R	10/6	1340	A	F	115	40	7	35
B/P	11/6	1930	A	F				
B/O	12/6	0839	A	F	110	35	7	35
P/R	12/6	2032	A	M	115	40	8	50
Y/P	13/6	0853	A	F	115	39	8	34
Y/P	13/6	0853	A	M	117	40	8	50
Y/O	15/6	1725	A	F	118	40	8	37

[1]. Two bands were placed on the right leg of each bird; colours were Black, White, Orange, Pink, Red, and Yellow.

Table 10. Radio transmitters attached to six California Quail.

BANDS	SEX	DATE ATTACHED	DATE REMOVED	LAST DETECTED	FREQUENCY (Hz)
O/O	F	30 May	~20 July		172.840
W/W	F	4 June		30 July	172.759
B/R	F	10 June	~10 June		172.939
P/R	M	12 June	~18 July		172.638
B/Y	M	13 June		14 August	172.679
Y/P	M	13 June	~10 July		172.939

Table 11. Breeding data for marked California Quail.

BANDS	MATE'S BANDS	DATES TRACKED	YOUNG/EGGS PRODUCED	
O/O	ub[1]	30 May-19 July	1 brood	(+1 clutch depred.)
W/W	W/B	4 June-30 July	0	(1 clutch depred.)
B/R	ub	10 June-26 Aug	2 broods	
P/R	Y/O	12 June-17 July	1 brood	
B/Y	B/P	4 June-14 Aug	1 brood	
Y/P	Y/P	13 June-30 July	0	
W/R	R/W	30 May-15 June	un[2]	(copulation 13 June)
Y/R	ub	30 May-1 Aug	0	(always with mate)
W/Y	-	3 June-13 July	0	(no mate)
B/W	un	23 May-19 July	1 brood	
B/O	ub	12 June-20 July	1 brood	
W/B	(Y/O)	3 June-20 July	0	(with Y/O after 13 July)
P/B	-	30 May-31 May	un	

[1]. ub=unbanded bird.
[2]. un=unknown.

Table 12. Fate of California Quail nests found in 1991.

FEMALE	DATE FOUND	CLUTCH	FATE	HABITAT
ub	13 May	24	abandoned	under rowboat, in garden
O/O	4 June	7	depred. ~6 June	grass, 20m from orchard
O/O	18 June	12	hatch ~10 July	pine scrub
W/W	18 June	12	depred. ~20 June	brush, under log

Table 13. Observations of broods of marked California Quail.

FEMALE	MALE	NUMBER OF YOUNG	APPROX. HATCH DATE	DATE OBSERVED	ESTIMATED SIZE OF YOUNG
B/R	ub	~6	5 June	10 June	"small"
un	B/W	5	10 June	19 July	1/2 grown
Y/O	P/R	~14	10 June	12 June 13 July	downy young 1/3 grown
B/O	ub	~7	25 June	20 July	1/3 grown
O/O	ub	12	10 July	13 July 17 July	female brooding downy young
B/P	B/Y	~10	22 July	25 July 13 Aug.	female brooding looked 2 weeks old
B/R	ub	~6	1 Aug.	26 Aug.	1/3 grown

un=unknown

4.4 DISCUSSION

California Quail were often observed feeding in orchards, especially in May and June but less often in July. The movement away from orchards in July appeared to be consistent for the four birds tracked during both June and July. In addition, all of the Quail observed feeding on identifiable foods (Table 14) in May and June were in orchards, while July observations were in non-orchard habitats. A larger sample of birds would be necessary in order to determine whether this pattern was a general trend for this population.

Quail which move out of orchard areas in July and August may be following patterns of food availability. Irrigated areas such as orchards may provide the first green herbs in the spring and thus be favoured as feeding areas early in the season. Another possibility is that the birds may be avoiding food contaminated with pesticides. Pesticides used and spray dates were not recorded for the orchards in the Quail study area; further studies should track movements of Quail in relation to the timing of sprays in the particular orchards where they feed. The Quail proved difficult to track in this study area, which is characterised by steep rocky ridges and deep gullies between and around the gently sloping orchard areas. Radio signals were often difficult to pick up and follow, since the Quail often roosted in gullies or sheltered areas between ridges. It was usually very difficult to visually observe the behaviour of Quail located by radio tracking, because they spent a lot of time in dense brush. Three of the four nests found during this study failed; one was abandoned while two were preyed upon. Our visits to the nests may have attracted mammalian predators, and such visits should be avoided in future work.

Table 14. Food items of California Quail, from observations in the field in 1991.

DATE	TIME	NUMBER OF BIRDS	ITEM(S) ON WHICH QUAIL WERE OBSERVED FEEDING	HABITAT
22 May	1835	2 pairs	fallen apple blossom petals	orchard
23 May	1507	1 male	insects	orchard
30 May	1153	1 pair	grass seed	orchard
30 May	1606	1 male	dandelion seeds etc.	orchard
4 June	1710	1 male	grass and various forbs	orchard
7 June	1417	1 pair	mostly grass seed	orchard
7 June	1507	1 pair	dandelion seeds and leaves, red clover leaves, various grasses, possibly insects	orchard
12 June	0859	1 female	mostly dandelion seeds	orchard
12 June	2010	1 male	clover blossoms	orchard
25 July	1013	1 pair	grass seeds	brush
30 July	0610	1 female	seeds	brush
30 July	1048	1 female	grass seeds	brush

No nests were found in orchards, though two nests were close enough to orchards that they may have received spray drift. Most orchards in the area had ground-level sprinklers, which may discourage ground nesters, and many of the orchards were frequently mowed.

While few conclusions can be drawn from the preliminary work presented here, there are indications of a number of patterns. We have shown that California Quail in the South Okanagan area commonly feed in orchards, on herbs, seeds and insects. Orchards may be favoured by these birds because the canopy provides cover from aerial predators and (if the ground vegetation is mowed) approaching ground predators can be detected early. Since they feed in orchards during the spray season, California Quail may be exposed to pesticides. However they may have mechanisms for avoiding exposure. Much of their time appeared to be spent around rather than in orchards, and nests were found near but not in orchards. Further, few Quail were observed in orchards after mid-June. The Quail may avoid recently-sprayed orchards when alternate feeding areas are available.

Further study should include:

1) a precise record of spray dates in the orchards where the Quail feed;
2) blood sampling before and after spraying to determine whether Quail are being exposed to cholinesterase-inhibiting insecticides;
3) tracking movements of Quail in a more systematic and less disruptive manner: eg., use two antennae and locate each bird by triangulation, to avoid disturbing the bird (especially if the bird is incubating);

4) Quail should be trapped and equipped with radio collars earlier in the season and baited traps should be removed during the period of tracking and observation, as they may affect the movements of the birds;

5) all radio-tagged birds should be located on each tracking foray, and these forays should be regular; for instance, twice a day for two days before and two days following spraying of an orchard, or once a week throughout the spray season to track seasonal movements, or several times a day on several days to determine effects of time-of-day.

5. PESTICIDE USE

5.1 OBJECTIVES

1. To determine seasonal patterns of use of pest control materials in orchards in the South Okanagan/Similkameen Region

5.2 METHODS

Information on pesticide use during the 1991 season was obtained for 43 of the 44 orchard blocks used for point counts of birds. The 28 growers were given pesticide-use questionnaire forms early in April, and 27 were contacted by telephone or in person at the end of our field season (late July). Two growers listed pesticides used without giving dates of application (3 blocks). Of the other 25 growers, 13 provided exact dates (24 blocks) and 12 gave approximate dates (16 blocks). All sprays for the season (March to September inclusive) were recorded, including both those applied before or during our bird survey period and sprays planned for later in the summer; dates for planned sprays were all approximate.

5.3 RESULTS

A total of 36 pest-control materials and thinning agents were used during the 1991 season by the growers surveyed (Table 14). These included eight organophosphate insecticides and miticides (Cygon, Diazinon, Ethion, Guthion, Imidan, Malathion, Supracide, Zolone), two carbamate insecticides (Pirimor, Sevin), and one organochlorine insecticide (Thiodan). Six of the materials reported, including four insecticides (Guthion, Ethion, Thiodan, Supracide), one blossom thinner (Elgetol), and one herbicide (Gramoxone), are listed in the BCMAFF (1991) Production Guide as highly toxic to people. At least four of the insecticides are highly toxic to birds (Cygon, Diazinon, Guthion, Imidan). Three of these are only moderately toxic to mammals (Cygon, Diazinon, Imidan), and their use is therefore not restricted.

Pest control materials were applied from March to September. Apple orchards received more pesticide applications and more applications of organophosphate insecticides than other fruits (Table 15). Overall, apple orchards were most heavily sprayed with chemicals in May; but the number of applications of organophosphate insecticides was highest in June and July (Table 16). The spray season was longest for peaches (Table 17) and shortest for cherries (Table 18). Pesticide use information for pears, prunes, apricots, and organically-grown fruits are presented in Tables 19-24.

Table 15. Pest control materials and thinning agents used by tree fruit growers in the South Okanagan/Similkameen area in 1991.

					LD50 (mg/kg body weight)		
Trade Name	Active Ingredient	Use[1]	Chemical Group	Target Pests[2]	Rat Oral	Rat Dermal	Redwinged Blackbird Oral
Amid Thin	naphthaleneacetamide	T	miscellaneous		1000		
Arctic Power	detergent	I	misc.	pear psylla			
Benlate	benomyl	F	benzimidazole	scab	>9600		
Captan	captan	F	dicarboximide	scab	8400		
Cygon	dimethoate	I	organophosphate	cherry fruitfly	215	400	6.60-17.8
Cyprex	dodine	F	aliphatic nitrogenous cpd	scab	566		
Diazinon	diazinon	I	organophosphate	campylomma,fruitworm,leafroller,thrips,scale	300	2150	2-3.16
Dipel	Bacillus thuringiensis	I	microbe	leafroller,fruitworm,spanworm,budmoth			
Dormant Oil	mineral oils	I	petroleum product	psylla,rustmite,aphids,scale,mealybug			
Easout	thiophanate-methyl	F	benzimidazole	scab	7500	>10000	
Elgetol	DNOC	T	dinitrophenol		24	200	
Ethion	ethion	M	organophosphate	mites	13	62	45-58
Ferbam	ferbam	F	carbamate	Coryneum blight, peach leaf curl	1000		
Fixed Copper	copper, fixed	F	inorganic	Coryneum blight, peach leaf curl			
Fruitone	naphthaleneacetic acid	T	misc.		5900		
Funginex	triforine	F	piperazine	powdery mildew	6000		
Gramoxone	paraquat	H	pyridine		100	80	
Guthion	azinphos-methyl	I	organophosphate	codling moth,peach twigborer,fruitworm	7	220	8.00-8.50
Imidan	phosmet	I	organophosphate	codling moth (in pear)	113	1550	17.8
Kumulus	wettable sulphur	F,M	inorganic	mildew, pear rust mite, scab			

Table 15 (Cont...) Pest control materials and thinning agents used by tree fruit growers in the South Okanagan/Similkanmeen area in 1991.

Trade Name	Active Ingredient	Use[1]	Chemical Group	Target Pests[2]	LD50 (mg/kg body weight) Rat Oral	Rat Dermal	Redwinged Blackbird Oral
Lime Sulphur	lime sulphur	F,M	inorganic	scab, mites, pear slug			
Malathion	malathion	I	organophosphate	cherry fruitfly	1000	4100	400
Morestan	chinohethionat	F	hydrocarbon	mildew	1100	2000	
Omite	propargite	M	organic sulphite	mites	1350	5000	
Pirimor	pirimicarb	I	carbamate	green aphids	147	>500	
Polyram	metiram	F	carbamate	scab	6200		
Princep	simazine	H	triazine compound		>5000	>3100	
Roundup	glyphosate	H	amino acid compound		4300	7900	
Rovral	iprodione	F	imide	brown rot	3700		
Safer's Soap	soap	I	misc.	pear psylla			
Sevin	carbaryl	T,I	carbamate	cherry fruitfly	400	>2000	56.2-150
Supracide	methidathion	I	organophosphate	scales,mites,leafroller,twigborer	25	150	
Thiodan	endosulfan	I	organochlorine	aphid,rustmite,fruitworm,leafhopper	18	74	
Vernolate	vernolate	H	carbamate		1400		
Ziram	ziram	F	carbamate	scab	1400		
Zolone	phosalone	I	organophosphate	codling moth (in apple)	82	>2000	

[1]. F=fungicide, H=herbicide, I=insecticide, M=miticide, T=thinning agent. [2]. Target pests were those targetted by the growers surveyed, in 1991.

Table 16. Mean number (range) of pesticide applications per orchard block, during the 1991 season.

Fruit	Number Blocks	Organo-phosphate	Organo-chlorine	Carbamate	Miscellaneous	Total
CONVENTIONAL ORCHARDS						
Apple	22	3.8 (0,6)	.23 (0,1)	1.0 (0,3)	4.9 (2,10)	10 (4,17)
Peach	5	1.0 (1,1)	.40 (0,1)	.50 (0,2)	2.8 (2,4)	4.8 (4,6)
Pear	3	2.0 (1,4)	.30 (0,1)		6.6 (3,10)	9.0 (7,12)
Cherry	3	1.0 (1,1)	.30 (0,1)	.30 (0,1)	3.0 (1,5)	4.7 (3,6)
Prune	2	2.0 (1,3)			2.5 (2,3)	4.5 (3,6)
Apricot	1	2.0	1.0		5.0	8.0
ORGANIC ORCHARDS						
All Fruit	7				4.0 (1,7)	4.0 (1,7)
OVERALL	36	2.9 (0,6)	.28 (0,1)	.75 (0,3)	4.5 (1,10)	8.4 (3,17)

Table 17. Monthly number of pesticide applications in apple orchards durings the 1991 season. Information was provided by 20 growers for 22 apple blocks.

Material[1]	Number of Blocks[2]	Chemical Class	April	May	June	July	August
INSECTICIDES							
Guthion 1	18	OP	1	1	15		
Guthion 2	17				3	13	
Guthion 3	14					3	10
Guthion 4	2					1	1
Diazinon 1	16	OP	3	11	1		
Diazinon 2	3			3			
Supracide	8	OP	7	1			
Zolone 1	2	OP			2		
Zolone 2	2					2	
Ethion	1	OP					
Thiodan	5	OC		1	2	1	1
Pirimor	1	C				1	
Dormant Oil	18	m	15	2			
Omite	2	m				2	
Dipel	1	m		1			
FUNGICIDES							
Polyram 1	8	C	3	3	2		
Polyram 2	5			4	1		
Polyram 3	1			1			
Captan 1	6	m		2	3		1
Captan 2	2				2		
Kumulus 1	3	m			3		
Kumulus 2	3				3		
Kumulus 3	2					2	
Cyprex 1	3	m		2	1		
Cyprex 2	2			1	1		

Table 17 (Cont...). Monthly number of pesticide applications in apple orchards during the 1991 season. Information was provided by 20 growers for 22 apple blocks.

Material[1]	Number of Blocks[2]	Chemical Class	April	May	June	July	August
Cyprex 3	1				1		
Benlate	2	m	1	1			
Easout	2	m	1	1			
Funginex 1	1	m	1				
Funginex 2	1		1				
Lime Sulphur	1	m		1			
BLOSSOM THINNERS							
Sevin	8	C		6	2		
Elgetol	5	m		5			
Amidthin	4	m		4			
Fruitone	1	m		1			
HERBICIDES							
Roundup 1	13	m	1	10	1		
Roundup 2	7				2	4	
Gramoxone 1	10	m		5	3		
Gramoxone 2	2					1	1
Princep	10	m		7	2		
ORGANOPHOSPHATES			11	16	21	19	11
TOTAL			34	74	51	29	14

[1]. Repeated applications are indicated, eg. 'Guthion 4' refers to a fourth application of Guthion. [2]. The numbers for each month do not always add up to the total number of blocks because one grower did not provide spray dates.

Table 18. Monthly number of pesticide applications in peach orchards during the 1991 season. Information was provided by five growers for five peach blocks. Two growers did not provide spray dates.

Material	Number of Blocks Sprayed	Chemical	March	April	May	June	July	Aug	Sept
INSECTICIDES									
Guthion	4	OP			1	1			
Supracide	1	OP		1					
Thiodan	2	OC							
Pirimor	1	C		1					
Dormant Oil	5	m	2	1					
FUNGICIDES									
Ferbam	1	C							
Captan	1	m							
Fixed Copper	3	m							3
HERBICIDES									
Gramoxone	3	m			1		1		
Vernolate	1	C							
Roundup	1	m			1				
Princep	1	m							

Table 19. Monthly number of pesticide applications in cherry orchards during the 1991 season. Information was provided by three growers for three cherry blocks. One block received two gramoxone applications.

Material	Number of Blocks	Chemical Class	April	May	June	July
INSECTICIDES						
Diazinon	1	OP	1			
Cygon	1	OP			1	
Malathion	1	OP				1
Thiodan	1	OC	1			
Sevin	1	C				1
Dormant Oil	2	m	2			
FUNGICIDES						
Captan	1	m	1			
Benlate	1	m	1			
Rovral	1	m			1	
HERBICIDES						
Gramoxone	2	m	1	1	1	
Roundup	1	m		1		

Table 20. Monthly number of pesticide applications in pear orchards during the 1991 season. Information was provided by three growers for three pear blocks.

Material	Number of Blocks	Chemical Class	March	April	May	June	July	Aug
INSECTICIDES								
Imidan1	1	OP				1		
Imidan2	1						1	
Imidan3	1						1	
Guthion	2	OP				2		
Ethion	1	OP				1		
Thiodan	1	OC	1					
ArcticPower1	2	m				2		
ArcticPower2	2					1	1	
ArcticPower3	2						1	1
ArcticPower4	1						1	
ArcticPower5	1							1
ArcticPower6	1							1
Safers Soap	1	m				1		
Dormant Oil	3	m	3					
FUNGICIDES								
Morestan	2	m		2				
Kumulus	1	m				1		
Lime Sulphur	1	m	1					
HERBICIDES								
Roundup1	2	m		1	1			
Roundup2	1						1	

Table 21. Monthly number of pesticide applications in prune orchards, during the 1991 season. Information was provided by two growers for two prune blocks.

Material	Number of Blocks	Chemical Class	March	April	May	June	July	Aug
INSECTICIDES								
Supracide	2	OP	1	1				
Guthion	1	OP			1			
Diazinon	1	OP				1		
Dormant Oil	2	m	1	1				
HERBICIDES								
Gramoxone1	1	m			1			
Gramoxone2	1							1
Roundup	1	m						1

Table 22. Monthly number of pesticide applications in an apricot orchard, during the 1991 season.

Material	Chemical Class	March	April	May	June	July	Aug
INSECTICIDES							
Guthion1	OP		1				
Guthion2						1	
Thiodan	OC			1			
FUNGICIDES							
Captan1	m	1					
Captan2			1				
Benlate1	m	1					
Benlate2			1				
Fixed Copper	m						1

Table 23. Monthly number of applications of pest control materials in organic apple orchards, during the 1991 season. Information was provided by four growers for five apple blocks.

Material	Number of Blocks	March	April	May	June	July
Dormant Oil	4		4			
Codling Moth Pheremone	5	1		4		
Leafroller Pheremone	3				1	2
Bacillus thuringiensis1	1		1			
Bacillus thuringiensis2	1			1		
Sulphur	1		1			
Cardboard Banding	2				1	1

Table 24. Seasonal timing of pest control in an organic cherry block and an organic pear block, in 1991.

Material	Timing
CHERRY	
Canola Oil	March
Bacillus thuringiensis	April
Shackly Soap	April
Lime Sulphur	July
PEAR	
Dormant Oil	March
Liquid Organic Cleaner	six times from June to August

5.4 DISCUSSION

Avian toxicity values were not available for most of the chemicals used in 1991 by tree fruit growers in this study. According to the available avian toxicity data (presented in Table 15), diazinon was the in-use chemical with the lowest acute LD50. Diazinon has been associated with bird kills in Canada (Frank *et al.*, 1991). In the U.S., the use of diazinon on golf course turf is restricted because of its association with numerous bird kills (Zinkl *et al.*, 1978; Stone and Knock, 1982). This chemical was used on 16 (73%) of the 22 apple blocks, one of the three cherry blocks, and one of the two prune blocks surveyed in our study. Cygon (dimethoate), Guthion (azinphos-methyl), and Imidan (phosmet) are also highly toxic to birds. Guthion was frequently used on apples (18 of 22 blocks, up to four applications per block), peaches (four of five blocks) pears (two of three blocks), prunes (one of two blocks), and apricots (applied twice on the one block surveyed). Cygon was used on one of three cherry blocks, and Imidan was applied three times to one of three pear blocks. In apples, the peak frequency of pesticide applications in May coincides with laying and incubation in American Robins, the most common nesting species in these orchards. In general, birds are most likely to abandon disturbed nests during the laying period.

The peak of organophosphate pesticide applications in June coincides with the nestling period in Robins; this is a period of high demand for food. The relationship between pesticide use and breeding biology is discussed in more detail in Section 3.3 above.

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APPENDIX 1

Miscellaneous Quail Observations:

Pairing of California Quail appeared to be consistent for the duration of the observation period for 4 of 5 pairs in which both birds were marked, and all 4 pairs in which only one bird was marked. The only exception to consistent pairing involved the marked pair P/R male and Y/O female, and the initially single male W/B. P/R and Y/O were observed together with their large brood on 12, 13, 15, and 24 June. The brood had apparently hatched around 10 June. Meanwhile, W/B had been observed on six occasions between 3 June and 23 June, always alone. At 0600h on 13 July, W/B was seen standing with Y/O beside a large hedge which was commonly used by about a dozen Quail as a night roost. No other Quail were visible at the time, and P/R was not detectable by radio. On the same afternoon, P/R was seen with a group of large young, presumably the brood hatched around 10 June. On 20 July, Y/O emerged from the same night roost at 0526h, flying directly to W/B, which was standing on the road nearby. They then walked along the road alone together, out of sight. Again, P/R was not detectable by radio from this location. This may be a case of serial polyandry by Y/O female, who may have been laying a second clutch sired by W/B during the period 13-20 July while P/R continued to raise her first brood.