IMPACT OF AGROFORESTRY PLANTATIONS GROWN WITH AGRICULTURAL DRAINWATER ON AVIAN ABUNDANCE IN THE SAN JOAQUIN VALLEY, CALIFORNIA

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Abstract: The diversity and abundance of birds was studied on 6 agroforestry plantations and 5 agricultural types (alfalfa, cotton, tomatoes, sugar beets, and fallow land) in the San Joaquin Valley, California, from June 1987 through May 1989. Based on 1,750 6-minute samples, taken during the 8 quarters of the study, 74 species of birds were observed in the agroforestry plantations while an additional 48 species were seen over and in close proximity to the plantations. Seven species of birds, based on 13,475 total sightings during the study, dominated tree plantation use: house finches (*Carpodacus mexicanus*) (19%), mourning doves (*Zenaida macroura*) (13%), yellow-rumped warblers (*Dendroica coronata*) (13%), song sparrows (*Melospiza melodia*) (10%), red-winged blackbirds (*Agelaius phoenicius*) (8%), brewer's blackbirds (*Euphagus cyanocephalus*) (8%), white-crowned sparrows (*Zonotrichia leucophrys*) (6%). Song sparrows (61%), red-winged blackbirds (23%), western meadowlarks (*Sturnella neglecta*) (6%), and house finches (4%) were the most common birds using agricultural habitats. Species similarity indices between the agroforestry plantations varied from 0.17 to 0.79 depending on the season-of-the-year. Species diversity indices varied from 3.40 to 6.40 per agroforestry site and averaged 4.12 (SE = 0.38, n = 48). Little nesting occurred in the eucalyptus until the trees were 3 years old; nest density in 1989 varied from 2 to 17 nests per ha. The oldest plantation (5 years old) had significantly more nesting activity than did younger sites ($P < 0.005$). Most of the nesting, based on 103 active nests in 1989, was by house finches (41%), mourning doves (31%), and brewer's blackbirds (16%). The agroforestry plantations provided needed nesting habitat and resting sites for migrating species of birds in an area devoid of this type of habitat. These agroforestry sites probably act as biological magnets for birds.

The combination of irrigation and soil conditions in the San Joaquin Valley of California have produced serious drainage-toxic chemical problems (USBR 1986, Barnum and Gilmer 1988, SJVDP 1989, Schroeder et al. 1988). Since 1985, > 21 agroforestry plantations have been established in the San Joaquin Valley as a part of the Agroforestry Demonstration Program to examine their potential as a method to reduce drainwater volume (Cervinka et al. 1987). *Eucalyptus camaldulensis* and *Casuarina cunninghamiana* are the predominant trees used in the program although other species of trees are also being considered for use. The high transpiration rate of these trees allows about 1 ha of trees to remove excess drainage water from about 10 ha of irrigated lands, depending on soil and crop conditions (Poore and Fries 1985).

We studied wildlife use on 6 agroforestry sites of the San Joaquin Valley Agroforestry Demonstration Program (Fig. 1) from 1 June 1987 to 30 May 1989. The sites, located between Mendota, Fresno County, and Stratford, Kings County, varied in size from just over 2 to 9 ha and have a variety of agricultural histories. Tree ages varied from 1 to 3 years at the start of this research. Studies of windbreaks and shelterbelts in the midwestern states indicated that stands of trees in otherwise treeless areas act as important habitat islands for wildlife (Yahner 1982). Agroforestry sites in the San Joaquin Valley of California probably also act as biological magnets, especially for birds (Chesemore et al. 1988).

The principle objectives of this study were to: (1) determine the species of birds utilizing the agroforestry plantations; (2) determine the relative abundance and diversity of birds in the agroforestry plantations; and (3) examine the avian community in surrounding agricultural habitats and compare its abundance and diversity with the agroforestry avian communities.

STUDY AREAS

The 6 sites of this study varied in size and shape. They were located on property belonging to the Allen (2.02 ha), Murrieta (9.43 ha), Wakefield (2.02 ha), Peck (3.24 ha), Thomsen (3.44 ha), and Haynes (4.57 ha) Ranches. The dimensions were highly variable. All sites were rectangular, except Haynes which was irregular in shape. With the exception of the Wakefield site, they were irrigated primarily with subsurface drainage water. Application of irrigation water, fertilization, and management of annual plants was variable. No mechanical or chemical control of animal species was practiced in the sites during the study.

Alfalfa, cotton, tomatoes, sugar beets, and fallow land study plots were located within 1 km of the various agroforestry sites. The crops were mature or near maturity when surveys were conducted. The crops represented the most commonly occurring agricultural types in the area. Landowner permission for access governed plot selection.

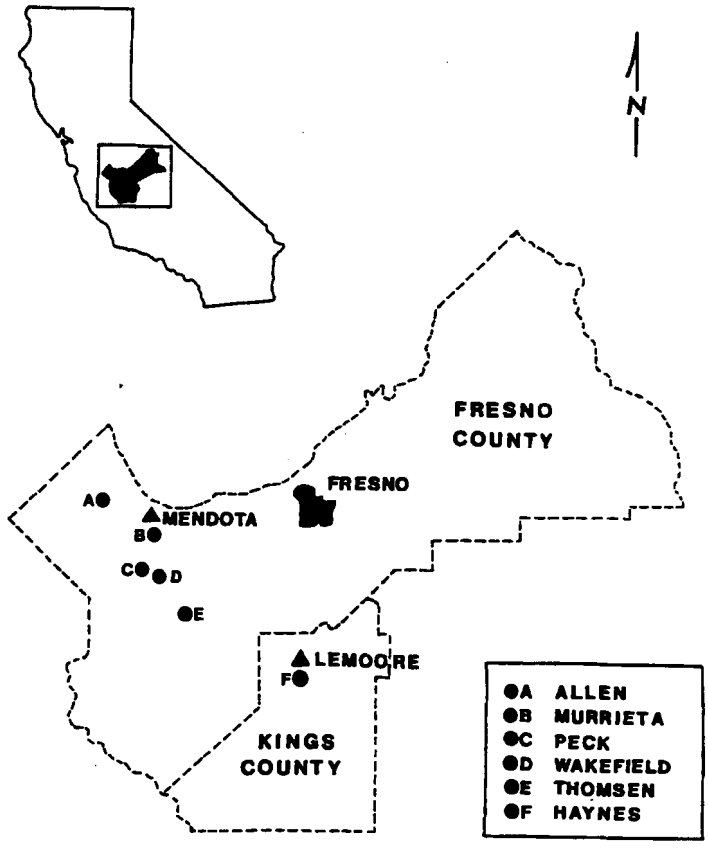

Fig. 1. Location of the 6 agroforestry study sites, San Joaquin Valley, California, 1987-1989.

METHODS

Bird observation stations were located in and around each site in order to maximize visibility and to canvas the entire site with each set of observations. The number of stations varied from 3 to 6 depending on the size of the site. The sampling scheme was modified from the North American Breeding Bird Survey (Bystrak 1981) and consisted of stationary counting locations with a 6-minute sampling duration. Surveys were conducted from sunrise to 1200 hrs and were started from a randomly chosen observation station to prevent any bias created by observer patterning. Birds were counted using binoculars and spotting scopes.

From 1 June 1987 to 30 May 1989, 1750 6-minute samples were taken. A total of 200 6-minute samples were taken for the agricultural types (cotton, alfalfa, tomatoes, sugar beets, and fallow land) from March 1988 to May 1988. Data recorded included species and location of bird in relation to the site. Birds observed while moving from one observation station to the next were used only for generating site specific bird lists. We also noted whether birds were seen in the site, flying over the site, or observed in the immediate vicinity (within 25 m) of the site. In this way, general or specific use of the sites by each species was gauged.

The detection of bird species richness (the number of species recorded per site) was enhanced by using 4 panel nylon mist nets (9 m x 2 m) in areas where high bird activity had been previously observed within the study sites. Nets were opened at sunrise and closed before noon. Each bird caught was banded with a U.S. Fish and Wildlife Service band (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1976).

Weekly systematic surveys of each site were conducted from 28 February to 30 June 1989 to determine nest densities and nest site selection for the 1989 nesting season. A combination pole and mirror device was used to check the contents of nests in the canopy (Parker 1972). When checking nests below eye level, the observer was careful to stand as far from the nest as possible.

Bird abundance measures were derived by dividing the total number of birds observed by the total number of 6 minute observation periods. A

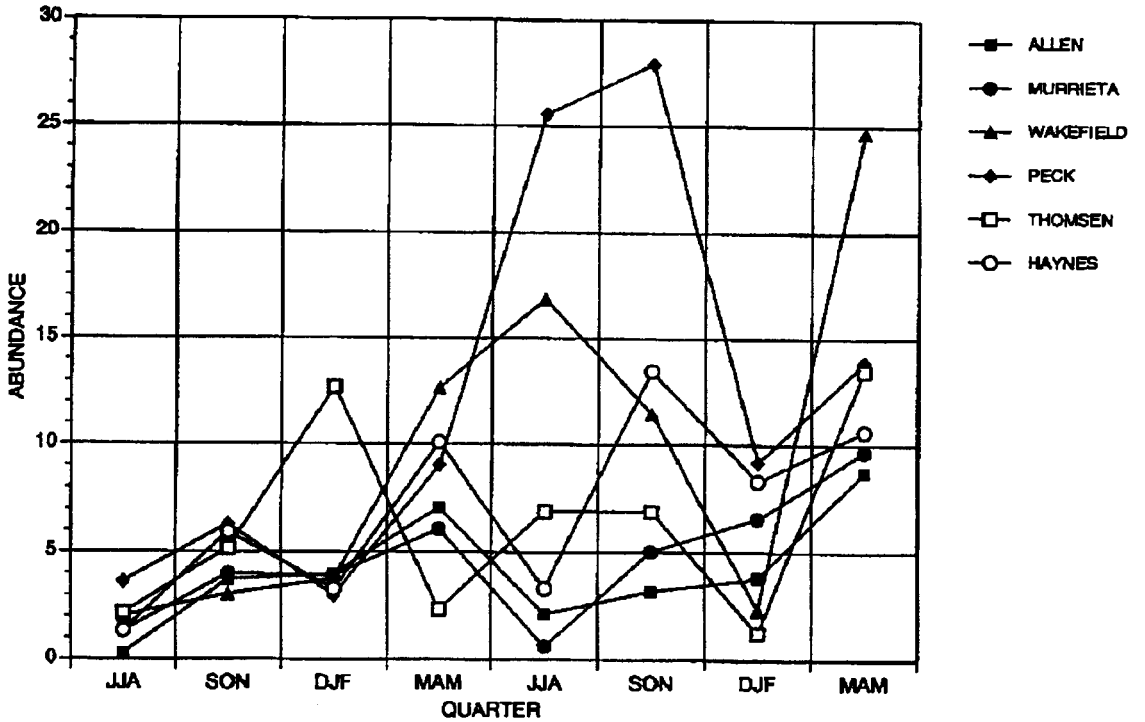

Fig. 2. Avian abundance (birds surveyed per sample) for 6 agroforestry plantations of the San Joaquin Valley, California, from 1 June 1987 to 30 May 1989.

significantly higher nesting rates than did eucalyptus ($P < 0.005$), even though casuarina composed less than 4% of the trees present on those sites having both kinds of trees. Nesting density among all sites varied from 2 to 17 nests per ha. Nine species were found to nest in the agroforestry sites for the 1989 nesting season (Table 4).

Discussion

Many studies of windbreaks and shelterbelts in midwestern states have shown positive correlations between the area of shelterbelts and bird species richness (Cassel and Wiehe 1980, Martin 1980, 1981). Although agroforestry

Table 2. Comparison of bird census summaries for agroforestry sites during a two-year period in the San Joaquin Valley, California 1 June 1987 to 30 May 1989 (n = number of 6 minute observation periods, B = total birds observed, A = mean birds observed/observation period).

	Year 1			Year 2			Total		
Site	n	B	A	n	B	A	n	B	A
Allen	108	451	4.18	120	536	4.47	228	987	4.33
Murrieta	210	910	4.33	240	1,315	5.48	450	2,225	4.94
Wakefield	148	869	5.87	160	2,217	13.86	308	3,086	10.02
Peck	148	892	6.03	160	3,064	19.15	308	3,956	12.84
Thomsen	111	677	6.10	120	857	7.14	231	1,534	6.64
Haynes	105	615	5.86	120	1,072	8.93	225	1,687	7.50
Total	830	4,414	5.32	920	9,061	9.85	1,750	13,475	7.70

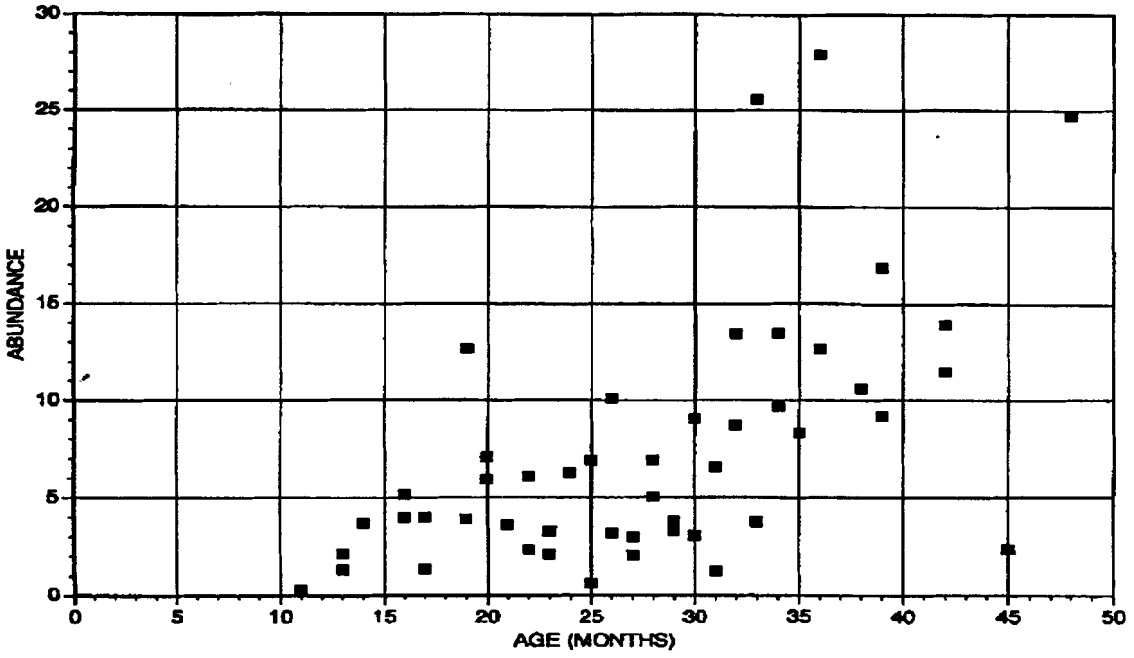

Fig. 3. Avian abundance of 6 agroforestry plantations of the San Joaquin Valley, California. Abundance (birds surveyed per sample) plotted against plantation age. A positive correlation exists between plantation age and avian abundance ($P < 0.001$).

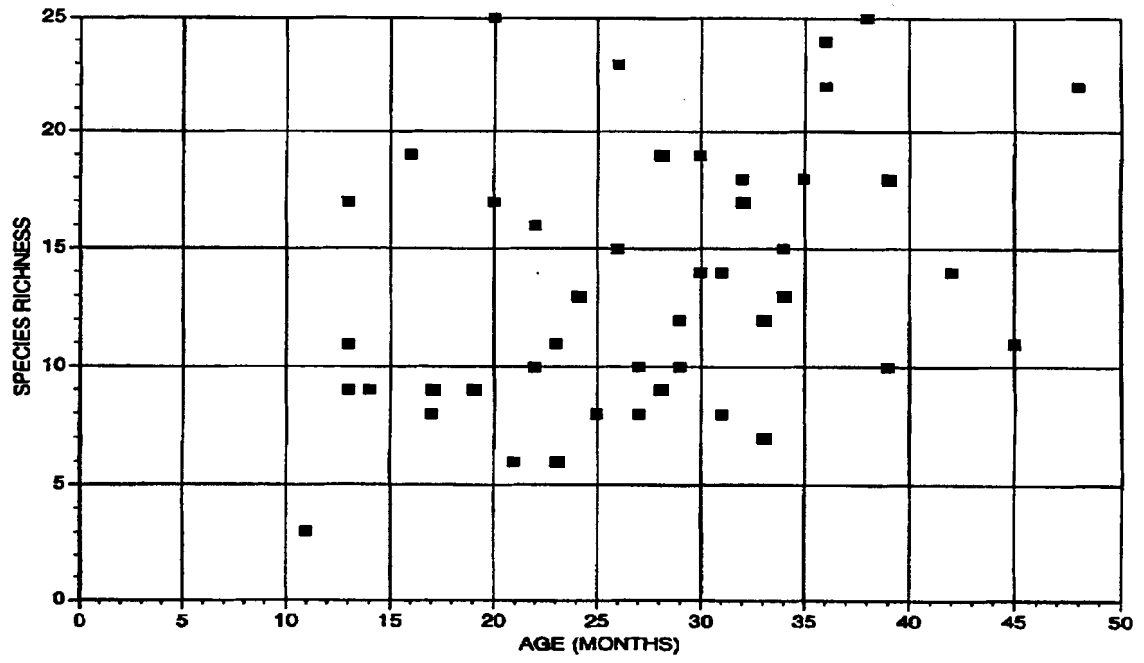

Fig. 4. Bird species richness of 6 agroforestry plantations of the San Joaquin Valley, California. Species richness (number of species present) plotted against plantation age. A positive correlation exists between plantation age and bird species richness ($P < 0.005$).

Table 3. Nests per site for 1989 nesting season for agroforestry plantations in the San Joaquin Valley, California. Active/ha = active nests per hectare. NA = not applicable (i.e., no Casurina present).

Site	Area (ha)	Eucalyptus	Casuarina	Combined	Active/ha
Allen	2.02	1	5	6	2.97
Murrieta	9.43	7	20	27	2.86
Wakefield	2.02	35	NA	35	17.33
Peck	3.32	4	13	17	5.12
Thomsen	3.64	5	3	8	2.19
Haynes	4.57	10	NA	10	2.19
Total	25.00	62	41	103	5.44

Table 4. Number of species nesting per site for 1989 nesting season for agroforestry plantations in the San Joaquin Valley, California (A = Allen, M = Murrieta; W = Wakefield, P = Peck, T = Thomsen, H = Haynes).

Species	A	M	W	P	T	H	Total
House Finch	3	6	26	3	3	1	42
Mourning Dove	1	7	5	6	5	8	32
Brewer's Blackbird	0	8	0	8	0	0	16
Western Kingbird	0	4	1	0	0	0	5
Brown-headed Cowbird	1	2	1	0	0	0	4
American Crow	1	0	0	0	0	0	1
American Robin	0	0	1	0	0	0	1
Blue Grosbeak	0	0	0	0	0	1	1
House Sparrow	0	0	1	0	0	0	1
Total	6	27	35	17	8	10	103

plantations showed no correlation between area and bird species richness, there was a positive correlation with plantation age and both species richness and bird abundance. A minimum area of a shelterbelt or agroforestry plantation may be the determining factor in species-area relationships. Martin (1980) studied 69 shelterbelts with an average area of 7,533 m^2 (SE = 778 m^2), whereas our study involved six plantations with an average area of 41,620 m^2 (SE = 11,220 m^2). If non-oceanic islands are to be included in island biogeographic theory of species-area relationships, then several factors could be affecting the lack of correlation in agroforestry plantations: (1) small sample size; (2) agroforestry plantations are intensively managed monocultures; and (3) a minimum area threshold may have been surpassed, thereby dampening species-area relationships.

The primary use of agroforestry plantations in the San Joaquin Valley of California is for reduction in volume of potentially toxic agricultural drainage water, although it appears clear to us that these plantations provide a valuable resource for both breeding and migratory birds. These relatively small wooded islands offer song and display perches for breeding birds, while providing nesting substrate and feeding areas for both resident and migratory birds. High bird species turnover rates would indicate that these relatively small wooded islands provide important habitat for many different species of birds.

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