GENERAL NOTES

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NOTES ON THE SESIID FAUNA OF SOUTHWESTERN WEST VIRGINIA

Additional key words: pheromones, faunal surveys, Appalachian region.

The Sesiidae is a relatively well studied moth family. In the past century, three comprehensive monographs have been written on the group (Beutenmuller 1901, Engelhardt 1946, Eichlin & Duckworth 1988), and several regional surveys have been conducted in the eastern United States (Neal et al. 1983 in Maryland, Sharp et al. 1978 in Florida, Sharp et el. 1979 again in Florida, Snow et al. 1985 in Georgia, Solomon et al. 1982 in Mississippi, and Taft & Snow in 1991 in the north central United States). These studies were aided enormously by the chemical isolation and synthesis of female sesiid sex attractants. In 1974 the synthesis of the (*Z,Z*)-3,13-octadecadien-1-ol acetate and of the (*E,Z*)-3,13-octadecadien-1-ol acetate was achieved by Tumlinson and Yonce respectively, and in 1983 the (*E,Z*)-2,13-octadecadien-1-ol acetate was isolated by Schwartz (Eichlin & Duckworth 1988). The use of these pheromones, alone or in different combinations, in the acetate or alcohol forms, has become the principal method for collecting male Sesiidae and has led to the discovery of many new species and to the elucidation of distributions and flight patterns.

The purpose of the present study is to establish the number of Sesiidae species flying in southwestern West Virginia, and to report on male responsiveness to different synthetic pheromone isomers in "pure" form and in different combinations.

Sampling was conducted over a period of five years, starting in May 1990 and ending in September 1994. Seven locations in two counties were sampled: five in Kanawha County and two in adjacent Putnam County. Three of the Kanawha County locations are situated in the city of Charleston (South Hills, Kanawha City, Coonskin Park). Kanawha State Forest is located at the southern boundary of the city, and Tupper Creek is a small rural community 10 miles north of the city. The South Hills and the Kanawha City locations are densely populated urban areas, with occasional patches of oak woodland. Coonskin Park is a partially developed hilltop that is well drained and rather dry. In addition to the deciduous trees typical for the area, it contains a large population of old pines. Kanawha State Forest is a large tract of undeveloped land containing a variety of microhabitats including gulches, ridges, river bottoms and hills with large tracts of deciduous forest interrupted by small clearings. Tupper Creek is a disturbed area along a small creek with an extensive growth of willow trees. Of the two Putnam County locations, one is situated 20 miles west of Charleston on a fir tree farm, and is surrounded by hills of uninterrupted deciduous forest. The other site, located 25 miles west of Charleston, is a disturbed area on the south bank of the Kanawha River, which supports an extensive growth of willow.

I used Multipher I traps and lures supplied by the IPM Great Lakes Company (Vestaburg, MI). The lures used in this study are listed in Table 1. In the traps I placed DDVP toxicant strips provided by IPM Great Lakes. In 1990, five traps baited with 97:3, ZZA, EZA, 1:1, and TRI lures were deployed in the South Hills area of Charleston. In 1991, eight traps baited with 97:3, ZZA, EZA, TRI, EZ-2,13-OH, EZ-2,13-A, EZ-3,13-OH, and 99:1 were used on the fir farm in Putnam County. In 1992, 2. eight traps baited with 97:3, EZA, ZZA, 1:1, TRI, 99:1, and EZ-3,13-OH were used in Kanawha State Forest. In 1993, five traps baited with 97:3, ZZA, EZA, 1:1, and 99:1 were used at Tupper Creek and three traps with 97:3, EZA, and ZZA in Kanawha State Forest. In mid June 1993, the 1:1 and 97:3 traps were moved from Tupper Creek to South Hills and the 99:1 trap to Kanawha State Forest. Then, in mid August all traps were moved to Kanawha City. In 1994, three traps baited with 97:3, ZZA, and EZA were used on the Kanawha River shore; three traps baited with 97:3, ZZA, and EZA in Coonskin Park and two traps baited with 1:1 and 2:1 in Kanawha City. At the beginning of August, the three Putnam County traps were moved to Kanawha City.

I began each baiting season in May, when the weather was reliably warm, and ended trapping in late September or early October. In the middle of July I added a new lure load to each trap, making sure that each trap carried the same lure throughout the season; new

TABLE 1. Pheromonal lures used in the present study and their abbreviations. Small percentages of impurities are omitted (these should be less than 1% with current synthesis techniques; Tumlinson 1979).

Abbreviation	Pheromone
97:3	97% (Z,Z)-3,13-octadecadien-1-ol acetate/3%(E,Z)-3,13-octadecadien-1-ol acetate
ZZA	100% (Z,Z)-3,13-octadecadien-1-ol acetate
EZA	100% (E,Z)-3,13-octadecadien-1-ol acetate
1:1	50:50 mixture of (Z,Z)-3,13-octadecadien-1-ol acetate/ (E,Z)-3,13-octadecadien-1-ol acetate
99:1	99:1 mixture of (E,Z)-2,13-octadecadien-1-ol acetate/ (Z,Z)-3,13-octadecadien-1-ol acetate
EZ-2,13-OH	100% (E,Z)-2,13-octadecadien-1-ol
EZ-2,13-A	100% (E,Z)-2,13-octadecadien-1-ol acetate
EZOH	100% (E,Z)-3,13-octadecadien-1-ol
TRI	20:1:3 mixture of (Z,Z)-3,13-octadecadien-1-ol acetate/ (E,Z)-3,13-octadecadien-1-ol/acetate (Z,Z)-3,13-octadecadien-1-ol
2:1	2:1 mixture of (E,Z)-3,13-octadecadien-1-ol acetate/ (E,Z)-3,13-octadecadien-1-ol

toxicant vapor tapes were added at the same time. Traps were placed on tree branches, either at the edge of the forest or on solitary trees, in clearings, at 1–1.5 m above ground with at least 20 m distance between traps. Whenever possible the traps were placed in a south or southwest orientation. I visited each trap once a week and emptied the buckets into labeled styrofoam cups that I took home to record the attracted specimens.

During this study 5080 male sesiids were captured, representing 24 species in 8 genera. Two of these, *Synanthedon kathyae* Duckworth & Eichlin and *Alcathoe carolinensis* Engelhardt, are new records for the state of West Virginia (T. D. Eichlin, pers. comm.). *Melittia cucurbitae* (Harris) was never lured to a pheromone trap but was netted on the foodplant (zucchini squash); since the main purpose of this study was to record as many species as possible for this area, I included it in the present listing. Table 2 lists all the recorded species, showing their yearly abundance at the sample sites. Table 3 gives the monthly distributions and abundances, and Tables 4–5 summarize the sensitivity of male sesiids to the different pheromone lures in this study.

Geographical and temporal trends. The records of *Synanthedon pictipes* (Grote & Robinson), *Podosesia aureocincta* Purrington & Nielson, *Carmenta bassiformis* (Walker) and *Synanthedon rileyana* (Hy. Edwards) show wide year to year fluctuations. Since these four species have at least one generation per year (*S. pictipes* is multivoltine), these fluctuations were probably geographical rather than temporal: one year the traps happened to be placed inside the territory of a population and attracted a large number of individuals; another year they were outside the population's territory and attracted fewer individuals. The number of attracted specimens suggests that these species are abundant inside well circumscribed colonies, which are doubtless centered around their foodplants.

Synanthedon rubrofascia (Hy. Edwards), *Synathedon scitula* (Harris), *Synanthedon decipiens* (Hy. Edwards), *Synanthedon fatifera* Hodges and *Carmenta ithacae* (Beutenmuller) had similar yearly/geographical fluctuations, but their numbers suggest much smaller and even more circumscribed colonies. It is worth noting the difference in abundance between *Synanthedon exitiosa* (Say) and *S. pictipes*. While these species both utilize wild and cultivated Rosaceae as hosts (Snow 1985, Eichlin 1988), *S. pictipes* appears to be much less abundant and more localized in southwestern West Virginia than *S. exitiosa*.

The records for *Paranthrene simulans* (Grote) and *Paranthrene pellucida* Greenfield & Karandinos confirm their two-year life cycle, with peak numbers being attracted in odd years. In the study area, both species appear to have similar abundance, both peak in the

TABLE 2. Yearly occurence of sesiid species in southwestern West Virginia based on captures in pheromone baited traps.

Species	Total	1990	1991	1992	1993	1994
Podosesia syringae	1564	67	613	176	488	220
Synanthedon exitiosa	1229	213	168	159	353	336
Podosesia aureocincta	651	3	93	547	7	1
Synanthedon pictipes	519	113	142	9	41	214
Carmenta bassiformis	235	6	2	56	147	24
Paranthrene simulans	181	0	89	4	87	1
Paranthrene pellucida	170	5	95	2	65	3
Alcathoe caudata	127	120	0	5	2	0
Synanthedon rubrofascia	115	33	3	1	17	61
Synanthedon rileyana	110	2	105	2	1	0
Synanthedon scitula	53	1	25	25	1	1
Synanthedon fatifera	29	2	14	0	0	13
Carmenta ithacae	20	0	3	0	0	17
Synanthedon acerni	13	0	2	2	0	9
Synanthedon acerrubi	12	0	11	1	0	0
Synanthedon decipiens	12	0	0	0	2	10
Sannina uroceriformis	12	0	12	0	0	0
Synanthedon viburni	11	3	0	1	0	7
Synanthedon rhododendri	8	0	0	1	0	7
Synanthedon kathyae	3	0	0	3	0	0
Vitacea polistiformis	2	0	0	2	0	0
Alcathoe carolinensis	2	0	0	1	0	1
Vitacea scepsiformis	1	0	0	0	1	0
Mellittia cucurbitae	1	0	0	0	1	0

same years, and their two-year cycles occurred in odd numbered years, contrary to Engelhard's statement (Engelhardt 1946:146) that even numbered years have peak flights of *P. simulans* in eastern United States.

Table 3 shows that the most productive months were June and July. All but one of the 24 species were caught during these two months, the exception being the later-flying *P. aureocincta*. Table 3 also shows distinct temporal segregation of *Podosesia syringae* (Harris) and *P. aureocincta*, the first having peak flight in May and the latter reaching peak flight in September. This lack of overlap is similar to other reports (Eichlin & Duckworth 1988) of an April–May peak for *P. syringae* and a peak after July for *P. auroecincta*. The closely related *P. simulans* and *P. pellucida* also showed a segregation in flight periods. *P. simulans* had peak flight in May, wheras *P. pelludica* peaked in June. Unfortunately, due to unfavorable weather, I never set traps up prior to May; therefore I lack data about the responsiveness of *P. simulans* to sex attractants in even earlier months.

The phenology for *S. pictipes* suggests two generations per year, with a more abundant spring generation in May and June (probably starting earlier) and a less abundant summer generation from July through October. This species is the only one that came to the traps in each month of the study. *S. exitiosa* had an extended flight season as witnessed by other authors (Eichlin & Duckworth 1988, Snow et al. 1985). *S. rubrofascia* exhibited a similar pattern, with a flight period extending from May to September and a peak in July. This matches the data reported by Snow et al. (1985), who were able to capture the moth from April to November in central Georgia. Eichlin and Duckworth (1988) give a shorter flight period (May and June). The specimens captured in this study did not resemble the illustration given by Eichlin and Duckworth in their monograph of the Sesiidae, but, having completely transparent forewings, they matched the illustration given by Taft and Snow (1991).

TABLE 3. Monthly occurrence of sesiid species in southwestern West Virginia based on captures in pheromone baited traps.

May		June		July		August		September		October	
Species	No.	Species	No.	Species	No.	Species	No.	Species	No.	Species	No.
P. syringae	1127	*P. syringae*	432	*S. exitiosa*	630	*S. exitiosa*	297	*P. aureocincta*	637	*P. aureocincta*	9
S. pictipes	163	*S. exitiosa*	239	*C. bassiformis*	137	*A. caudata*	94	*S. exitiosa*	55	*S. pictipes*	1
P. simulans	124	*S. pictipes*	192	*S. rileyana*	93	*S. pictipes*	64	*A. caudata*	28		
S. exitiosa	8	*P. pellucida*	119	*S. pictipes*	78	*C. bassiformis*	45	*S. rubrofascia*	18		
S. acerni	8	*P. simulans*	57	*P. pellucida*	50	*S. rubrofascia*	26	*S. pictipes*	21		
S. uroceriformis	5	*S. fatifera*	28	*S. rubrofascia*	49	*S. rileyana*	14	*C. bassiformis*	3		
S. viburni	2	*S. rubrofascia*	21	*S. scitula*	30	*S. scitula*	11				
S. acerrubi	2	*C. bassiformis*	14	*C. ithacae*	15	*S. decipiens*	10				
S. rubrofascia	1	*S. scitula*	12	*S. viburni*	5	*P. aureocincta*	5				
P. pellucida	1	*S. acerrubi*	10	*A. caudata*	5	*C. ithacae*	4				
		S. uroceriformis	7	*P. syringae*	5	*S. viburni*	1				
		S. rhododendri	6	*S. decipiens*	3	*S. rhododendri*	1				
		S. acerni	5	*S. kathyae*	3						
		S. viburni	3	*V. polistiformis*	2						
		S. rileyana	3	*S. fatifera*	1						
		S. decipiens	2	*A. carolinensis*	1						
		C. ithacae	1	*S. rhododendri*	1						
		A. carolinensis	1	*V. scepsiformis*	1						
				M. cucurbitae	1						

TABLE 4. Responsiveness of sesiid moths to pheromone lures. Numbers are percentages of the total number of individuals for a given species (sums may not be 100% due to rounding). Numbers in parentheses are the total number of individuals for a given species. No *M. cucurbitae* individuals were taken in the pheromone baited traps.

Species	97:3	EZA	ZZA	TRI	1:01	99:1	EZ-2,13-OH	EZ-3,13-OH	EZ-2,13-A	2:01
P. syringae (1564)	73	1	24	1	1	—	—	—	—	1
S. exitiosa (1229)	81	2	12	1	2	—	—	—	—	1
P. aureocincta (651)	59	—	19	21	—	—	—	—	—	—
S. pictipes (519)	1	94	4	—	—	—	—	1	—	—
C. bassiformis (235)	8	77	6	5	—	1	—	—	—	1
P. simulans (181)	46	2	7	2	2	6	—	1	30	—
P. pellucida (170)	80	1	10	1	6	1	—	—	—	—
A. caudata (127)	7	—	—	92	—	—	—	—	—	—
S. rubrofascia (115)	3	—	1	—	76	—	—	—	—	19
S. rileyana (110)	—	4	2	—	—	—	83	10	—	—
S. scitula (53)	11	80	7	1	—	—	—	—	—	—
S. fatifera (29)	34	—	65	—	—	—	—	—	—	—
C. ithacae (20)	—	100	—	—	—	—	—	—	—	—
S. acerni (13)	15	—	46	—	—	—	—	—	—	—
S. acerrubi (12)	—	—	—	—	—	83	—	—	16	—
S. uroceriformis (12)	—	—	—	—	—	—	100	—	—	—
S. decipiens (12)	66	—	16	—	8	—	—	—	—	8
S. viburni (11)	27	63	—	—	—	—	—	9	—	—
S. rhododendri (8)	62	—	25	—	—	12	—	—	—	—
S. kathyae (3)	—	—	33	—	—	—	—	66	—	—
V. polstiformis (2)	—	—	—	—	— 100	—	—	—	—	
A. carolinensis (2)	—	50	—	—	50	—	—	—	—	—
V. scepsiformis (1)	—	—	—	—	— 100	—	—	—	—	
M. cucurbitae (1)	—	—	—	—	—	—	—	—	—	—

TABLE 5. Comparison of responsiveness of sesiid species to different pheromone lures in three different studies.

Species	Present Study	Eichlin & Duckworth, (1988)	Taft & Snow, (1991)
P. syringae	97:3, ZZA	ZZA	ZZA
S. exitiosa	97:3, ZZA	ZZA	ZZA
P. aureocincta	97:3, TRI, ZZA	TRI	ZZA, 50/50 ZZA/EZOH
S. pictipes	EZA	EZA	EZA
C. bassiformis	EZA	ZZA, ZZOH	ZZA, 50/50 ZZA/ZZOH
P. simulans	97:3, EZ-2, 13-A	96:4, ZZA	ZZA, 99:1
P. pellucida	97:3, ZZA	no mention	ZZA
A. caudata	TRI	no mention	ZZOH, 1:1
S. rubrofascia	1:1, 2:1 EZA/EZOH	1:1	1:1
S. rileyana	EZ-2, 13-OH	EZOH, EZOH/EZA	EZOH, 50/50 ZZA/EZOH
S. scitula	EZA	ZZA	ZZA
S. fatifera	ZZA, 97:3	ZZA	ZZA
C. ithacae	EZA	ZZA, 97:3	EZA
S. acerni	ZZA, 97:3, light	ZZA, light	ZZA, 50/50 ZZA/ZZOH
S. acerrubi	99:1	EZ-2, 13-A	99:1
S. decipiens	97:3, ZZA	ZZA/EZA, ZZA/EZOH	ZZA, 1:1
S. uroceriformis	EZ-2, 13-OH	EZOH, EZOH/ZZOH	no mention
S. viburni	EZA	EZA	EZA
S. rhododendri	97:3, ZZA	ZZA	no mention
S. kathyae	EZOH, ZZA	ZZA	no mention
V. polistiformis	99:1	99:1	99:1
A. carolinensis	EZA, 1:1	EZA, 3:1	no mention
V. scepsiformis	99:1	ZZA/EZA, ZZA/EZOH	no mention
M. cucurbitae	on foodplant	99:1	99:1

Synanthedon acerni (Clemens) and *Synanthedon acerrubi* Engelhardt had a shorter flight period than given by other sources (Eichlin & Duckworth 1988, Snow et al. 1985, Taft & Snow 1991). Both species were active only in May and June. *Sannina uroceriformis* Walker was active in May and June (see Eichlin & Duckwoth 1988, Snow et al. 1985). *Synanthedon viburni* Engelhardt had a more extended flight period (May through August) than *S. fatifera*, which was active almost exclusively in June. *S. scitula*, *S. rhododendri* (Beutenmuller), *S. rileyana*, *S. decipiens*, *C. bassiformis*, *C. ithacae* and *Alcathoe caudata* (Harris) had flight periods similar to those observed by other authors (Eichlin & Duckworth 1988, Snow et al. 1985, Taft & Snow 1991). *A. carolinenesis* had an earlier activity period (June and July) compared to other sources (Eichlin & Duckwoth 1988, Snow et al. 1985, Sharp et al. 1978). This is somewhat surprising, considering that both Snow's and Sharp's groups collected their specimens to the south of West Virginia (Georgia and Florida, respectively). The flight of *S. kathyae* corresponded with the period given by Eichlin and Duckworth (1988), as did that of *Vitacea polistiformis* (Harris) and *Vitacea scepsiformis* (Hy. Edwards).

Pheromonal responses. The 97:3 blend proved to be the most generalized attractant, yielding a total of 15 species. It was the main lure for seven species: *S. exitiosa*, *P. pellucida*, *P. syringae*, *S. decipiens*, *S. rhododendri*, *P. aureocincta* and *P. simulans*. It also attracted a large percentage of all *S. fatifera*, *S. viburni*, *S. acerni* and *S. scitula*. The "pure" ZZA lure also attracted 15 species but was the main attractant for only two species: *S. fatifera* and *S. acerni* (note that 38% of *S. acerni* individuals were caught at black light, usually early in the morning; this was the only species that came to black light during this study, see Eichlin and Duckworth 1988). The "pure" EZA pheromone was attractive to 11 species; for six of those it was the main attractant: *C. ithacae*, *S. pictipes*, *S. scitula*, *C. bassiformis*, *S. viburni* and *A. carolinensis*. Surprisingly, the TRI mixture was only moderately attractive for *P. aureocincta*, for which it was originally formulated (Nielsen et al. 1979), attracting only 21% of the 651 individuals of *P. aureocincta* caught. In contrast, 59% of the individuals responded to the 97:3 mixture. Sharp and Eichlin report the same weak attraction of this combination for *P. aureocincta* (1979).

The TRI lure proved strongly attractive to *A. caudata* (92% of the total). *A. caudata* displayed a specific pheromone responsiveness: of 120 specimens caught in 1990 in South Hills, 117 responded to the TRI lured traps and only three to the 97:3 traps. In 1991 no individuals came to the TRI trap in Putnam County. In subsequent years I did not have the TRI lure, but the 97:3 lure attracted 5 and 2 individuals respectively in Kanawha State Forest and Tupper Creek. This suggests that *A. caudata* occurs in large, well circumscribed colonies, and the individuals exhibit a strong attraction to the TRI mixture. *Synanthedon acerrubi* Engelhardt and *Sannina uroceriformis* Walker exhibited the same geographical confinement, but the numbers caught indicate small colonies or weak responses. The 1:1 mixture attracted *S. rubrofascia* (76% of the total). The 99:1 blend lured all the *V. polistiformis* and *V. scepsiformis* caught and was highly attractive for *S. acerrubi* (83% of the total). EZ-2,13-OH was a highly specific lure for *S. uroceriformis*, (100% of the total). It also proved attractive to *S. rileyana* (83% of the total). The EZOH isomer was a less effective attractant for *S. rileyana* (10% of the total), and lured two individuals of *S. kathyae* (66%). No *M. cucurbitae* males were attracted to any pheromone traps, even though a 99:1 baited trap was kept close to the patch with zucchini-squash plants, where the only individual caught during this study was netted.

Table 5 summarizes male sesiid responsiveness to different sex lures in three different studies: the present work, Eichlin and Duckworth (1988) and Taft and Snow (1991). In the present study *C. bassiformis* exhibited a strong affinity toward the EZA lure (77% of the total), whereas the other two studies reported the ZZA isomer as most attractive. Since these were the same EZA baited traps that attracted 94% of *S. pictipes* individuals, and since it is known that the presence of as little as 1% of the ZZA isomer as an impurity would significantly reduce the response of the moth to the lure (Tumlinson 1979), it can be concluded that the EZA lure used in this study was of high purity. The same scenario occurred with *S. scitula*: 80% of the individuals in the present study came to the EZA traps, while the other studies found the ZZA isomer to be the main lure. It would be interesting to find out if circumscribed and geographically isolated populations of the same species could be responsive to different pheromone isomers (there is some indication that attractancy to pheromones or mixtures may vary depending on what other species fly in the same area; Eichlin, pers. comm.).

In conclusion, with 24 species recorded here, southwestern West Virginia appears to have a rich sesiid fauna. Further collecting will doubtless add more species to the list (while this paper was being prepared, a male *Synanthedan sigmoidea* (Beutenmuller) was taken at Kanawha City in a 99:1 trap). The abundance data reported here should be interpreted with caution: pheromone bait trap captures of males in specific locations may or may not reflect the overall abundance of particular species in the whole region. For instance, *M. cucurbitae* is certainly a common species in southwestern West Virginia where host plants are available, yet no individual was caught in any of the baited traps. It would be erroneous to conclude from this study that *M. cucurbitae* is a rare species.

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MIGRATORY ACTIVITY IN *VANESSA CARDUI* (NYMPHALIDAE) DURING 1992 IN WESTERN NORTH AMERICA, WITH SPECIAL REFERENCE TO EASTERN CALIFORNIA

Additional key words: migration, population dynamics, weather, Owens Valley.

Migrations of *Vanessa cardui* (L.) were unusually large in southwestern North America during 1991–1992, the largest since 1968 and 1973, providing a rare opportunity to study the complex mass behavior and population dynamics of this species (cf. Woodbury et al. 1942, Abbott 1951). Here we summarize 1992 records for the region and present observations made by one of us (DG) in Inyo County, California. The methods follow those outlined in Giuliani and Shields (1995). Migration rates here (no./5min/15m) are arbitrarily classified as light (1–29), small-scale (30–49), medium-scale (50–99) and large scale (>99). *Vanessa cardui*, like the monarch (*Danaus plexippus* L.), has a southward return migration during the summer and fall (Emmel & Wobus 1966, Shapiro 1980, Myers 1985, Nelson 1985, Giuliani & Shields 1995).

Small numbers of migrating *V. cardui* were reported during February and March 1992 in California, including: NW at Hemet (29 February, 12–22 March), NNW in San Diego County (9–10 March), NW–WNW near Bakersfield (11 March), NNE–WNW in Inyo County (15–17 March), and WSW in Ventura County (19 March) (pers. obs.; J. F. Emmel, in litt.; McKown 1993). A light migration was seen between Barstow and Yucca Valley on 26 March (McKown 1993). Many northward migrators were seen near San Diego (27–30 March) (R. Larson, pers. comm.), and there were several newspaper accounts of *V. cardui* plastering windshields during late March in the southern San Joaquin Valley.