The butterfly assemblage of Jasper Ridge Biological Preserve

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Abstract

The butterfly assemblage at Jasper Ridge Biological Preserve (JRBP) was inventoried between March and September 2006. The survey protocol was a modified Pollard walk and included weekly counts along eight 250-m long transects. Each transect was located in a different major vegetation association within or just outside the preserve. During the 22 weeks of surveys, a total of 1242 individuals belonging to 37 species were identified, of which 27 species can be considered residents at JRBP (that is, complete their entire life cycle within JRBP). The most abundant resident species were associated with open woodland and, to a lesser extent, with chaparral and grassland. The sum of the number of individuals of each species recorded across the season provides an index of abundance that can serve as a baseline for future monitoring that aims to detect trends in abundance or species richness.

Introduction

Although much scientific research on butterflies has been conducted at Jasper Ridge Biological Preserve (JRBP) since the 1960s, the spotlight has been mostly on *Euphydryas editha bayensis* (Bay Checkerspot butterfly), a subspecies listed as threatened under the federal Endangered Species Act, and on *Euphydryas chalcedona* (Variable Checkerspot butterfly). Little has been published about other species of butterflies present at the preserve (but see Blair & Launer, 1997).

As part of a postdoctoral program sponsored by the Swiss National Science Foundation, I initiated a project with two goals. First, I aimed to obtain a list of the butterfly species present at Jasper Ridge Biological Preserve and estimate their relative abundances. Second, I sought to provide a scientifically valid protocol that could be followed in the future to detect trends in abundance or species richness of butterflies.

Methods

Monitoring protocol

The monitoring protocol itself was a modified Pollard walk (Pollard, 1977; Pollard & Yates, 1993). I monitored a set of eight 250 m fixed-route transects, each of which was located in a different, homogenous type of vegetation at the preserve or adjoining habitats. The locations of these transects

were selected in order to represent the major vegetation associations and topographic conditions at the preserve (Table 1, Figure 1).

Each transect was visited once per week during the 2006 flight season (06 March through 06 September) for a total of 22 weeks. Transects were visited between 10:00 A.M. and 5:00 P.M. with wind speed < 2 m s^{-1} and temperature between 12.4 and 36.5 °C (average 23.7 °C). Transects were walked in one direction at a slow and even pace (~1-2 km h^{-1}) for a duration of 15-20 minutes. Each butterfly (Rhopalocera: Papilionoidea and Hesperioidea) seen within a virtual 5 m observation cube projected ahead of the observer was counted (Figure 3). Individuals were either identified on sight (sometimes using close-focus binoculars) or captured with a net for closer examination. Identification was based on Glassberg (2001) and Scott (1986). Nomenclature follows the North American Butterfly Association (Cassie *et al.*, 2001). When this method is used by experienced observers, differences in the weekly counts of each observer are negligible (Pollard, 1977). Analyses of the suitability of this protocol to detect individual species are detailed in Pellet (2008).

Data summary and analysis

The sum of all weekly counts for a given species yields an index of annual population size (Moss & Pollard, 1993; Pollard & Yates, 1993). These indices typically are closely correlated with absolute population size for closed local populations (Thomas, 1983). Because broods were not distinguishable for most multivoltine species, I could not extract indices of abundance for each brood. Species evenness was also computed for each transect. This diversity index quantifies how equal the populations of each species are quantitatively. It is lowest when one species dominates the assemblage and highest when all species have equal abundance.

Data on the natural history of the butterflies were collated from Scott et al. (Scott, 1986) and Opler (Opler *et al.*, 2006). Vagility (the tendency to move about or disperse) was categorized following Fleishman et al. (1997) as tens of meters, hundreds of meters, thousands of meters, or more. When species-specific data on vagility were not available, the vagility category was estimated on the basis of information for closely related species (within the same genus) using Fleishman et al. (1997). Residence status at JRBP (resident or migrant) was categorized using all the previously cited sources.

Results

During the 22 weeks of monitoring, I recorded a total of 1242 individuals of 37 species across the eight transects (Table 2 and Figure 5). None of the species observed is listed as endangered or threatened by either the United States or the state of California.

The most abundant species by far was *Coenonympha tullia* (Common Ringlet). This species accounted for more than half (54%) of all individuals identified and was the only species observed in every transect. The second most abundant species was *Euphydryas chalcedona,* with 156 individuals observed across seven transects. Only two other species were also present in seven transects: *Ochlodes agricola* (Rural Skipper) and *Celastrina ladon* (Spring Azure). *Lycaena arota* (Tailed Copper) was also relatively abundant, although present in only four transects.

The 37 species recorded at JRBP can be categorized according to their primary vegetation association during the surveys and other life history characteristics such as larval host plant use, residency status at JRBP, and vagility (Table 3). The most abundant resident species observed at JRBP all were associated

with open woodland and, to a lesser extent, with chaparral and annual grassland. Open woodland, chaparral, and grassland are the primary vegetation alliances of JRBP).

The woodland transect had the highest species richness (22 species identified). This transect also had the highest overall abundance of butterflies (i.e., pooled across species) (Figure 4). The riparian, chaparral, and grassland transects also had relatively high species richness (17, 16, and 15 species, respectively). Evenness of species (i.e., the distribution of individuals among species) was highest in the riparian transect, followed by the residential and the woodland transects. The serpentine transect had the lowest species richness (4 species identified) and evenness. The ruderal transect had the lowest abundance of butterflies, with 33 individuals recorded during 22 visits (on average 1.5 butterfly observed per visit).

Discussion and conclusions

Monitoring protocol

General butterfly monitoring protocols derived from Pollard walks (Pollard, 1977; Pollard & Yates, 1993) are widely used in temperate countries, including the United States (Blair & Launer, 1997; Mattoni *et al.*, 2001; Nelson & Epstein, 1998). This method has been demonstrated to be adequate to detect trends in species abundance over time, although long term time-series (15-20 years) might be necessary to make scientifically credible inferences about trends (Pollard *et al.*, 1995; Thomas, 2005; VanStrien *et al.*, 1997). The time and money necessary to obtain long-term data on butterfly abundance is often limited. To date, however, there are no scientifically credible, alternative methods for obtaining data on trends in abundance. Data obtained during 4th of July butterfly counts (Swengel, 1990) or unstandardized random wanderings are not amenable to statistical analysis. These methods can only provide anecdotal information about butterfly abundance (such as the detection of large migratory events; e.g. *Vanessa cardui* [Painted Lady] or *Danaus plexippus* [Monarchs]).

Another drawback of the method I used is its inability to efficiently detect canopy-inhabiting species (such as some Theclinae), because many of those species will not be apparent in the observer's line of sight. The distribution and abundance of such species are likely to be underestimated to an unknown extent (e.g. *Satyrium auretorum* [Gold-Hunter's Hairstreak]). Therefore, more specific methods must be used for species whose behavior makes them difficult to detect. Some individuals in the canopy can be coaxed lower by rattling the vegetation with a long pole. When a particular species (such as the extirpated *Euphydryas editha bayensis*) is the focus of study, searches should concentrate on locations or vegetation types that are most likely to be inhabited (e.g., where the most abundant population was known to occur). Additionally, only a small fraction of all serpentinic grassland has been monitored. It is therefore likely that some specialized species have gone undetected (e.g. *Hesperia lindseyi* [Lindsey's Skipper], see Harrison & Shapiro, 1988).

During the 33 days of field work, I accessed transects via alternate routes within the preserve and walked the perimeter of the preserve. During this time, I did not detect any species that had not been seen in my eight fixed-route transects. This suggests that transect location and sampling intensity were adequate to identify most species of butterflies at JRBP.

Historical data, relative abundance and population trends

There are few historical data on the butterflies of JRBP other than the two *Euphydryas* species that have been the focus of scientific research for several decades; these two species alone account for nearly three dozen scientific publications from Jasper Ridge. By comparison, other butterflies have received little study: *Coenonympha tullia* was the subject of one dissertation (Weissman 1972), and *Junonia coenia* the subject of one journal publication (Bowers 1984). Student papers have examined *C. tullia* and the two *Erynnis* species (Fine 1969, Jeffers 1980). Only one peer-reviewed publication (Blair and Launer 1997) provides a list of species observed within the boundaries of the preserve. Of those, only *Hesperia comma* (Common Branded Skipper) was not observed in 2006. This is not surprising given the low abundance of the species reported by Blair and Launer. The species list compiled in 2006 is likely to grow if other species that might have been missed are detected or if different migrant species occur in the area. Additional historical comparisons may be possible from the data of Moldenke (1972).

The index of abundance (sum of weekly counts) for 2006 can be used as a data point for future analysis of trends in abundance. However, cumulative precipitation in spring 2006 was the greatest on record (150 years) for the San Francisco Bay area. Because the phenology and abundance of most butterflies varies in response to weather patterns early in the season (Pollard & Yates, 1993, p. 90), abundances in 2006 may be low for many species. Similarly, because the flight season has been delayed for early emerging species, it is to be expected that the phenology observed this year has been delayed or shortened for spring species (Figure 5). Furthermore, it is likely that some multivoltine species aborted their first brood (or had a negligible first brood) in 2006 (e.g., *Plebejus acmon* [Acmon Blue]). The duration of the flight season and the number of broods for individual species (which will affect annual abundance) is likely to vary among years. Butterfly transect data collected by Arthur Shapiro during the last 30 years in several inland sea-level sites (Suisun Marsh, West Sacramento, North Sacramento, Rancho Cordova) and one Inner Coast Range site (Gates Canyon) demonstrate unequivocally for all of them that spring 2006 was catastrophic for short-term butterfly abundance and diversity (A. Shapiro, pers. comm., data available from http://butterfly.ucdavis.edu). Hopefully, future butterfly surveys at Jasper Ridge will be conducted under more average weather conditions.

Abundance indices are species-specific and cannot be used for interspecific comparisons. Abundance among species cannot be compared directly unless data are corrected for differences in detectability among species (Thomas, 2005).

Natural history

Although the majority of resident species of butterflies with low vagility (tens to hundreds of meters) were associated with both oak-madrone woodlands and chaparral, the primary vegetation associations indicated in Table 3 are not definitive. It is likely that species will occur in other vegetation types. Similarly, the larval host plants listed in Table 3 are collated from references for North America and are not specific to the San Francisco peninsula. Local host plant use may be much more specific than the families listed in Table 3. However, local natural history data are lacking for most species. Specific data on larval host plants exist for *Euphydryas chalcedona,* which feeds on *Mimulus aurantiacus* (Sticky Monkey Flower), and for *Plebejus acmon,* which feeds on *Lotus purshianus* (Pursh's Lotus).

Threats to JR butterflies

Because no previous data on the trends in presence or abundance of most species exist for JRBP, this report does not attempt to consider the probability of persistence or conservation status of butterflies at

JRBP. However, some considerations about the preservation of JR butterfly diversity can be detailed here.

Several species have been declined dramatically in northern California (e.g. *Coenonympha tullia*, *Ochlodes agricola* and *O. sylvanoides*, A. Shapiro pers. comm.). These species are therefore good candidates for detecting early trends in population abundance.

Species diversity at JR is mostly due to the diversity of vegetation associations available. Most associations within the preserve being close to their climax stage, or, in the case of grasslands, maintained by natural disturbance or herbivory, succession is unlikely to modify drastically their characteristics. However, the disruption of natural processes, such as fire, is likely to create artificial habitats unlike those with which species have co-evolved (e.g. the pile-up of fuel can modify herbaceous ground cover).

Another threat to native butterflies at JR is the spread of non-native plants. There is evidence that exotics can act as larval host plants for as much as one third of California butterflies (Graves & Shapiro 2003). The evolutionary consequences of host plant diversification are unfortunately hard to predict and there is only anecdotal demonstration of a toxic effect of non-native plants on native caterpillars (Graves & Shapiro 2003). Exotic plants also constitute a diverse nectar source for butterflies. *Centaurea solstitialis* (Yellow star-thistle) is for instance one of the most used nectar sources at JR, especially in late season, after *Aesculus californica* (California Buckeye) has finished flowering. The impact of non-native plants as nectar sources is believed to be low.

From a geographical viewpoint, the area and peri-urban location of JR strongly affect both the availability of habitat for specialized butterflies and the connectivity with other populations. As the case of *E. editha bayensis* sadly demonstrates, the extinction of a species with low mobility in the preserve is unlikely to be compensated by a natural recolonization event from a nearby source. It is therefore especially important to preserve adequate conditions for resident species by both reducing artificial management and restoring natural disturbance regime (e.g., through prescribed burns).

Conclusion

The inventory of JRBP butterflies that I conducted during 2006 is the first effort toward a standardized characterization of the butterfly assemblage at JRBP. About half of the species known to occur in San Mateo or Santa Clara counties have been observed within the 481 hectares of the Preserve. The presence of multiple native vegetation associations and the topographic complexity of JRBP probably support this relatively high species richness. The data collected in 2006 may serve as a baseline for future efforts to monitor species richness or abundance of butterflies at JRBP.

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regions has been edited in the California Natural History Guides collection (Shapiro & Manolis, 2007). It is highly recommended.

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Table 1: Location of butterfly transects

Transect	Location	Latitude	Longitude
Grassland	Along the fire road, between trailheads 15 and 17.	37°24'5.66"N	122°13'8.83"W
Serpentine	Along the fire road, between trailheads 3 and 9.	37°24'17.53"N	122°13'28.46"W
Woodland	Along the fire road, between trailheads 4 and 6.	37°24'27.11"N	122°13'46.69"W
Scrubland	Along trail 10.	37°24'6.15"N	122°13'27.80"W
Chaparral	Along trail 9.	37°24'9.62"N	122°13'32.89"W
Residential	Along the horse trail between Goya and Escobar gates.	37°23'56.92"N	122°12'46.46"W
Riparian	Along trail 13, between Searsville lake and Leonard's Bridge.	37°24'0.98"N	122°14'14.86"W
Ruderal	Along the horse trail at Boething Nursery, starting at the gate.	37°24'26.98"N	122°12'50.22"W

Table 2: Relative abundance (number of individuals) of butterfly species recorded at Jasper Ridge Biological Preserve, 2006.

Species		Grassland	Serpentine	Woodland	Chaparral	Scrubland	Residential	Ruderal	Riparian	Total
Papilio zelicaon	Anise Swallowtail			3	2					5
Papilio rutulus	Western Tiger Swallowtail			16				1	11	28
Papilio eurymedon	Pale Swallowtail			14	7	1	2		1	25
Colias eurytheme	Orange Sulphur	1				1				2
Anthocharis sara	Pacific Orangetip						12			12
Pieris rapae	Cabbage White						2	3	15	20
Pieris napi	Margined White								2	2
Danaus plexippus	Monarch	1		1		1				3
Coenonympha tullia	Common Ringlet	90	89	165	120	141	38	19	3	665
Cercyonis pegala	Common Wood Nymph	5		22	7	8		1		43
Limenitis lorquini	Lorquin's Admiral						15	1	20	36
Adelpha bredowii	California Sister	1		1						2
Junonia coenia	Common Buckeye	2		1		1		1		5
Vanessa atalanta	Red Admiral						2		1	3
Vanessa cardui	Painted Lady	2			2			1	3	8
Polygonia satyrus	Satyr Comma								6	6
Nymphalis californica	California Tortoiseshell			1	1	1				3
Nymphalis antiopa	Mourning Cloak						1		5	6
Euphydryas chalcedona	Variable Checkerspot	19		8	51	20	55	2	1	156
Chlosyne palla	Northern Checkerspot			1	2					3
Phyciodes mylitta	Mylitta Crescent	1					5	1	9	16
Speyeria coronis	Coronis Fritillary	1								1
Habrodais grunus	Golden Hairstreak	1								1
Satyrium auretorum	Gold-hunter's Hairstreak			2						2
Satyrium saepium	Hedgerow Hairstreak			1	5					6
Satyrium tetra	Mountain Mahogany Hairstreak			2						2
Callophrys augustinus	Brown Elfin			1	3					4
Strymon melinus	Gray Hairstreak					2				2
Lycaena arota	Tailed Copper			7	5		28		16	56
Celastrina ladon	Spring Azure		2	3	1	3	4	2	4	19
Plebejus acmon	Acmon Blue	4	9		1	10				24
Ochlodes sylvanoides	Woodland Skipper			2	1		1		10	14
Ochlodes agricola	Rural Skipper	1	1	7	1		3	1	6	20
Poanes melane	Umber Skipper								10	10
Erynnis propertius	Propertius Duskywing	1		3						4
Erynnis tristis	Mournful Duskywing			23	1		2			26
Pyrgus communis	Common Checkered-Skipper	1		1						2
Species richness		15	4	22	16	11	14	11	17	37
Species evenness		0.45	0.32	0.56	0.51	0.42	0.73	0.67	0.89	0.55
Total number of individuals		131	101	285	210	189	170	33	123	1242

Table 3: Primary vegetation association, larval host plants, vagility (1: tens of meters, 2: hundreds of meters, 3: thousands of meters, 4: greater than thousands of meters) and residency status at Jasper Ridge Biological Preserve. Resident species are believed to complete their entire life cycle within the preserve.

Name		**Vegetation associations**	**Larval host plants**	**Vagility**	**Residency**
Papilio zelicaon	Anise Swallowtail	Open areas	Herb Apiaceae	3	Resident
Papilio rutulus	Western Tiger Swallowtail	Woodland and suburban areas	Tree Salicaceae, Betulaceae, and Rosaceae	3	Resident
Papilio eurymedon	Pale Swallowtail	Chaparral, woodland, and riparian	Shrub and tree Rosaceae	3	Resident
Colias eurytheme	Orange Sulphur	Open areas	Herb Fabaceae	4	Non-resident
Anthocharis sara	Pacific Orangetip	Open areas	Herb Brassicaceae	2	Resident
Pieris rapae	Cabbage White	Open areas	Herb Brassicaceae	3	Resident
Pieris napi	Margined White	Moist woodland openings	Herb Brassicaceae	2	Resident
Danaus plexippus	Monarch	Open areas	Herb Asclepiadaceae	4	Non-resident
Coenonympha tullia	Common Ringlet	Grassland, meadow, and open woodland	Herb Poaceae	2	Resident
Cercyonis pegala	Common Wood Nymph	Moist grassy areas	Herb Poaceae	2	Resident
Limenitis lorquini	Lorquin's Admiral	Openings and edges of moist forest	Shrub and tree Salicaceae	2	Resident
Adelpha bredowii	California Sister	Oak woodland	Tree Fagaceae	2	Resident
Junonia coenia	Common Buckeye	Open areas and bare ground	Herbs of different families	4	Non-resident
Vanessa atalanta	Red Admiral	Open areas	Herb Urticaceae and Moraceae	4	Non-resident
Vanessa cardui	Painted Lady	Open areas	Herb Asteraceae and other families	4	Non-resident
Polygonia satyrus	Satyr Comma	Moist woodland	Herbs, vines, shrubs, and trees of different families	3	Resident
Nymphalis californica	California Tortoiseshell	Chaparral and woodland	Shrub Rhamnaceae (*Ceanothus* sp.)	3	Non-resident
Nymphalis antiopa	Mourning Cloak	Deciduous woodland	Tree Salicaceae and Betualceae	3	Non-resident
Euphydryas chalcedona	Variable Checkerspot	Chaparral and open forest	Herbs and shrubs of different families	2	Resident
Chlosyne palla	Northern Checkerspot	Chaparral and open woodland	Herb and shrub Asteraceae	2	Resident
Phyciodes mylitta	Mylitta Crescent	Wide variety of vegetation types	Herb Asteraceae	2	Resident
Speyeria coronis	Coronis Fritillary	Woodland openings, chaparral, and sagebrush	Herb Violoceae	3	Non-resident
Habrodais grunus	Golden Hairstreak	Chaparral and oak woodland	Tree Fagaceae	1	Resident
Satyrium auretorum	Gold-hunter's Hairstreak	Chaparral and oak woodland	Tree Fagaceae (*Quercus* sp.)	2	Resident
Satyrium saepium	Hedgerow Hairstreak	Chaparral and oak woodland	Shrub Rhamnaceae (*Ceanothus* sp.)	2	Resident
Satyrium tetra	Mountain Mahogany Hairstreak	Chaparral and oak woodland	Shrub Rosaceae (*Cercocarpus* sp.)	2	Resident
Callophrys augustinus	Brown Elfin	Chaparral and brushy forest edges	Herbs, shrubs, vines, and trees in different families	1	Resident
Strymon melinus	Gray Hairstreak	Open areas	Herb Fabaceae and other families	4	Non-resident
Lycaena arota	Tailed Copper	Chaparral, scrubland, and open woodland	Shrub Grossulariaceae	1	Resident
Celastrina ladon	Spring Azure	Woodland openings and edges	Shrubs and trees in different families	2	Resident
Plebejus acmon	Acmon Blue	Open areas	Herb and shrub Polygonaceae and Fabaceae	1	Resident
Ochlodes sylvanoides	Woodland Skipper	Chaparral, sagebrush, and woodland	Herb Poaceae	1	Resident
Ochlodes agricola	Rural Skipper	Woodland, riparian, and chaparral	Herb Poaceae	1	Resident
Poanes melane	Umber Skipper	Woodland openings	Herb Poaceae	3	Resident
Erynnis propertius	Propertius Duskywing	Open oak woodland	Tree Fagaceae	2	Resident
Erynnis tristis	Mournful Duskywing	Oak woodland	Tree Fagaceae	2	Resident
Pyrgus communis	Common Checkered-Skipper	Open areas	Herb Malvaceae	4	Non-resident

Figure 1: Transect locations at Jasper Ridge Biological Preserve, 2006

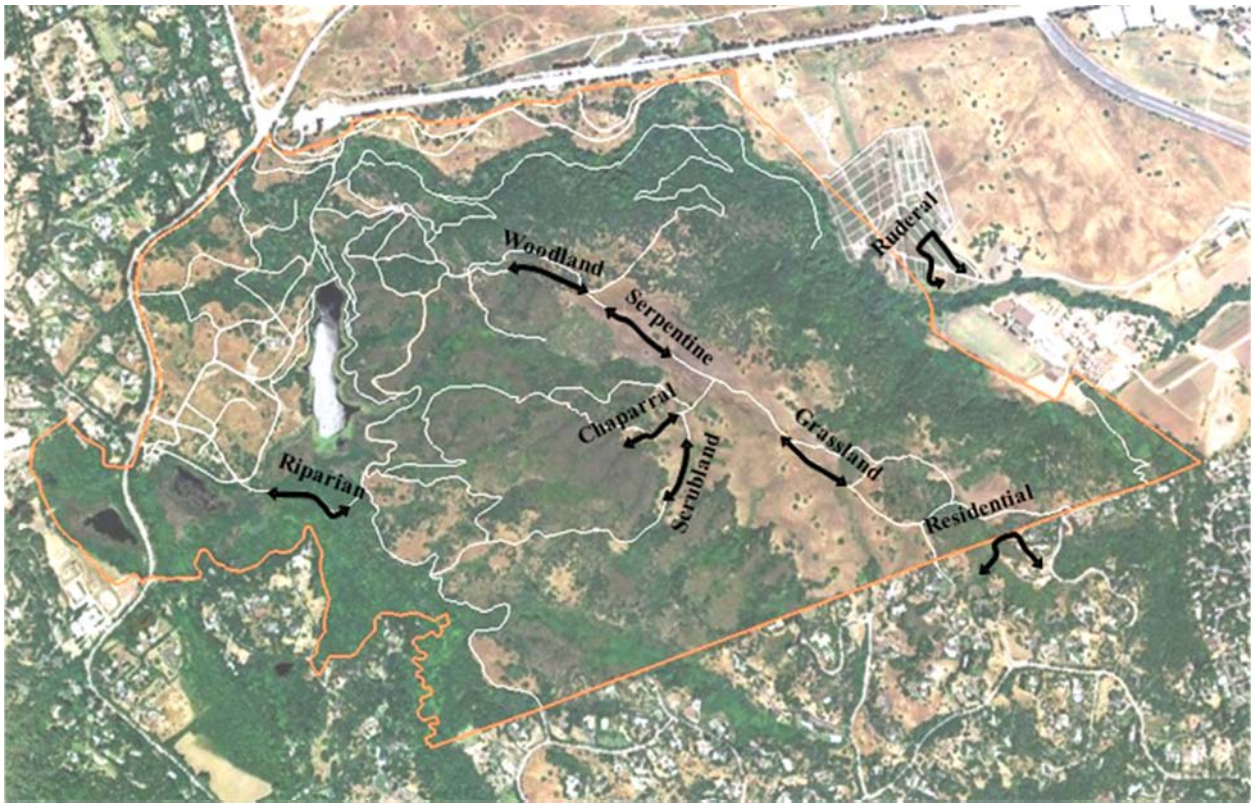

Figure 2: View of the transects on August 14, 2006


Grassland


Serpentine


Woodland


Chaparral


Scrubland


Residential


Ruderal


Riparian

Figure 3: A virtual 5 m observation cube projected ahead of the observer. Reproduced from Thomas (2005).

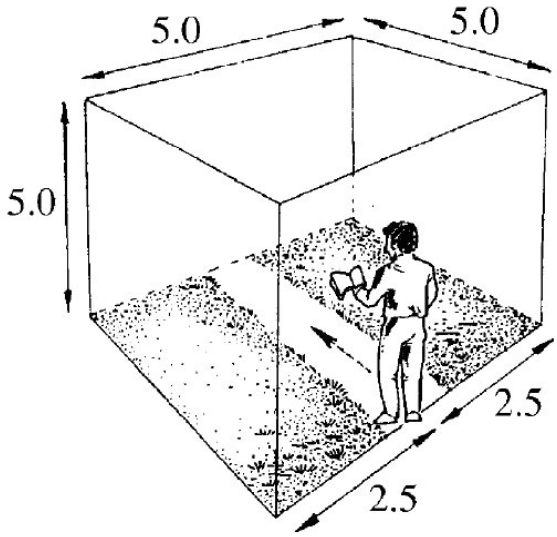

Figure 4: Relationship between butterfly species richness (number of species observed) and total number of individuals in different transects at Jasper Ridge Biological Preserve.

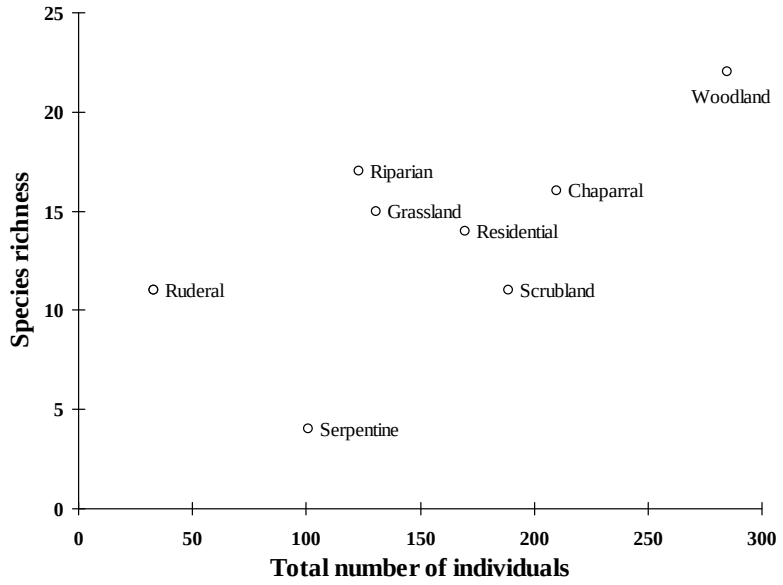

Figure 5: 2006 phenology of butterfly emergence at Jasper Ridge Biological Preserve.