Insect biodiversity in three Sydney urban parklands with differing levels of human usage*

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ABSTRACT

As a senior student geography project, the effect of human activity on insect biodiversity in urban Sydney was undertaken at three locations with differing levels of recreational use. The locations were Lane Cove National Park, Bicentennial Park, and Cabarita/ Queen Elizabeth Parks, Concord. Within these locations, three sites were chosen and light trapping was conducted at each site for 30 minutes on each of five separate occasions, three weeks apart, between February and May, 2001. Data from the three sites at each location were pooled for analysis. The trapped insects were from 12 of the 24 insect Orders, and the total insect taxa from each location ranged from 60-70 in February to around 20 in May. The mean insect species followed a similar trend and declined from 38-47 in February to 12-13 in May. The total and mean insect species did not differ significantly between locations at each time point, indicating that the local environments at each site maintained flying insect biodiversity, despite human recreational use. It was considered that the diversity of local vegetation that provided both food and shelter was the major determinant influencing insect biodiversity, and should be considered during planning for recreational use in urban parklands.

Key words: Urban bushland, insect diversity, human impacts.

Introduction

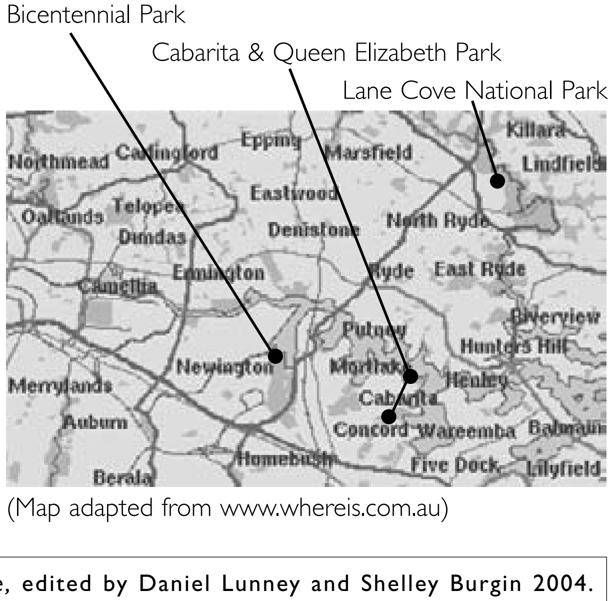
For the rational design, planning and management of recreation and conservation areas in urban regions, sustainable and functioning ecosystems need to be considered. Not only have ecosystems with abundant species diversity proved more productive in agriculture, they are also more stable and resilient to invading species (Wilson 1992; Tilman 2000). Ongoing studies have also indicated that ecosystems are unique and of intrinsic value, for regenerated systems never replicate the original (Wilson 1992; Tilman 2000). Strategic management of functional ecosystems requires and relies upon supportive scientific data for which fieldwork is indispensable. Towards this end, and assuming a greater urgency as habitat is threatened and climate change is occurring, larger vertebrates have been well studied (Margules and Pressey 2000), while invertebrates are often neglected. Yet insects are the most diverse and successful of all fauna and are essential for most functional ecosystems (Wilson 1992).

It was considered that research on insect biodiversity in natural bushland and urban and regenerated parkland with differing levels of human usage in Sydney would provide an instructive insight into the vitality of each environment within the three different areas. It was anticipated that such a study would provide valuable information and feedback to the Councils and Boards/ Trusts of Lane Cove National Park (LCNP), Bicentennial Park (BP) and Cabarita/Queen Elizabeth Park (Cab/QE), who permitted the fieldwork to be conducted in their particular locations, as well as providing an interesting topic for the Senior Geography Project. Consequently, this report details the insect species caught by light trapping in LCNP, BP and Cab/ QE Park during three-weekly field trips from February-May 2001.

Materials and Methods

Organisation of locations/sites

Three locations were chosen (Figure 1): Lane Cove National Park, Bicentennial Park and Cabarita and Queen Elizabeth Park. Lane Cove National Park was chosen as natural bushland, BP as regenerated bushland with moderate human usage, and CAB/QE Park as heavily utilised urban parkland. Each location contained three sites; two were near water; and one was surrounded by bushland. In LCNP, the fieldwork was carried out at area 13, 14 and close to area 15 on the regional map of LCNP. In BP, two sites were located on the peninsula leading to the bird observation hut and a third was adjacent to bushland at the Study Centre. Two sites in Cab were located in wooded grassland adjacent to the oval, and the third site was next to bushland in QE Park.

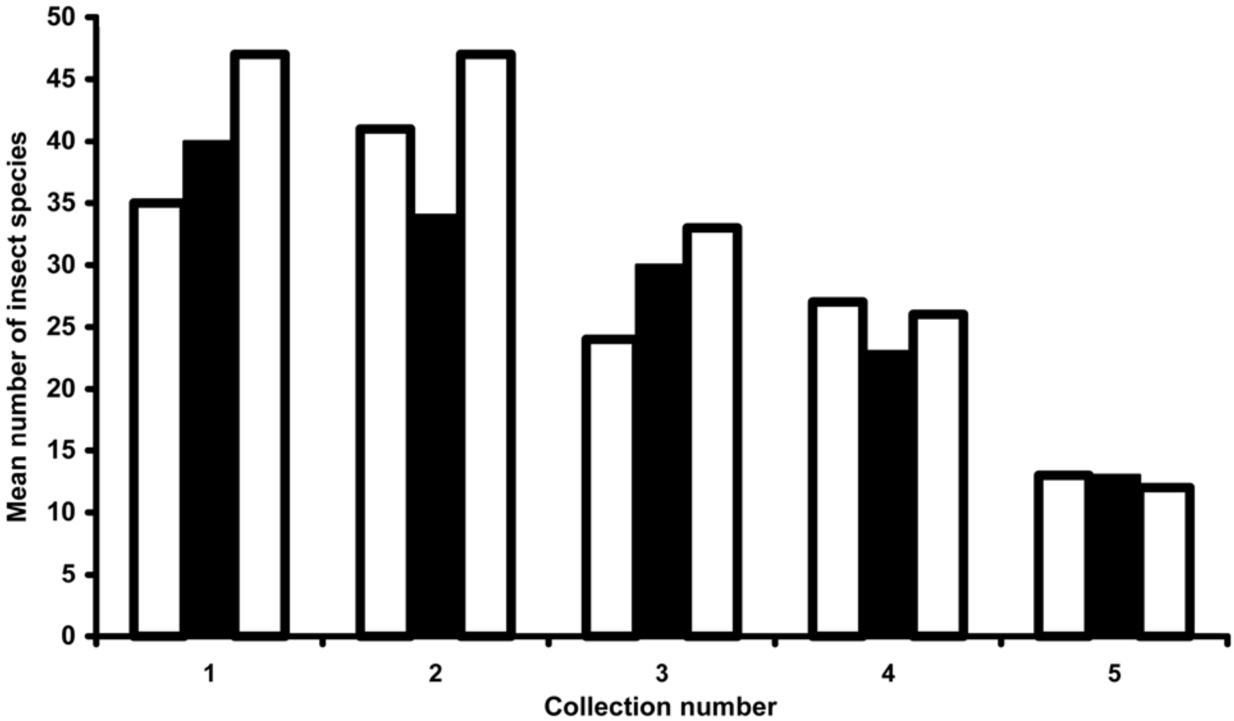


(Map adapted from www.whereis.com.au)

Pp 124 - 130 in *Urban Wildlife: more than meets the eye,* edited by Daniel Lunney and Shelley Burgin 2004. Royal Zoological Society of New South Wales, Mosman, NSW.

Table 1. Weather conditions for light trapping (LCNP, Lane Cove National Park; BP, Bicentennial Park; Cabarita & Queen Elizabeth Parks).

Date	Area	Temp (^{0}C)	Cloud	Moon	Wind Speed
23rd Feb	LCNP	Warm26	None	None	None
24th Feb	BP	Warm 25	Scattered	None	Sl. ENE
25th Feb	Cab/QE	Warm 23	Overcast	None	Sl.ENE
16th March	LCNP	Mild 23	Overcast	None	mod. NE
17th March	BP	Mild 21	None	None	Mod. SW
18th March	Cab/QE	Mild 22	Overcast	None	Sl. SW
6th April	LCNP	Mild 21	None	Full	None
7th April	BP	Mild 21	None	Full	None
8th April	Cab/QE	Mild 21	Scattered	Full	Sl. NE
26th April	LNCP	Mild 20	None	New	None
27th April	BP	Mild 20	Scattered	New	None
28th April	Cab/QE	Cool 17	Scattered	New	Str. SW
18th May	LCNP	Cool 14	Scattered	None	Sl. SE
19th May	BP	Cool 15	None	None	Sl. SE
20th May	Cab/QE	Cool 15	None	None	None



Collections were made on 23-25 February (1), 16-18 March (2), 6-8 April (3), 27-29 April (4) and 16-18 May (5). Data is presented for each collection time (left to right) as Lane Cove National Park (clear), Bicentennial Park (filled) and Cabarita/Queen Elizabeth Parks (clear).

Figure 2. Mean numbers of insect species collected at the light trap at the 3 locations.

Experimental design

Three locations were each visited five times in this project. Ninety minutes were spent at each location; 30 minutes trapping at each of the three sites in that location. Each location was visited on consecutive nights; three nights every three weeks for a total of five visits on 23-25 February (1), 16-18 March (2), 6-8 April (3), 27-29 April (4) and 16-18 May (5). A total of 22.5 hours of fieldwork was completed for this project.

Trapping protocol

On each occasion, the weather conditions were recorded, including temperature, cloud cover, phase of moon and wind speed and direction. After dusk, a white sheet was spread underneath the UV light that was placed in the centre. Attracted insects were collected in test tubes and placed in a jar containing five drops of ethyl acetate, ready to remove later for identification. This was carried out the same way throughout the whole of the fieldwork, as previous experience had shown that light traps were a simple but effective means of attracting and collecting insects (Muirhead-Thomson

1991). Once the insects were killed, they were placed in plastic bottles containing naphthalene flakes for storage.

Identification of species

The insects were classified to Order and identified to morphospecies. The results for total numbers within each Order (with taxa in parentheses) were tabulated for each location, site and sampling time (Tables 2-4). For the identification of morphospecies, non-technical books on Australian insect classification and identification were used (Zborowski and Storey, 1995; Hangay and German, 2000).

Presentation of data

For convenience, it was assumed for each location that the greatest number of taxa within each Order from one of the three sites would also contain all of those taxa from the other two sites (given the relative proximity of sites within each location). A preliminary check of three collections generally confirmed this premise. The total number of morphospecies from any one location on a particular night was, therefore, calculated from the sum of the maximum number of species for each Order, collected at one of the three sites within that location.

Table 2. Total numbers of insects collected at LCNP (numbers of species in parentheses)

Insect order	Collection number and site														
	1 – 24th February			2 – 17th March			3 – 7th April			4 – 28th April			5 - 17th May		
	Site 1	2	3	Site 1	2	3	Site 1	2	3	Site 1	2	3	Site 1	2	3
Odontata			3(1)			6(1)			3(1)						
Isoptera	3(1)	2(1)													
Blattodea															
Mantodea			1(1)		1(1)	1(1)									
Orthoptera		8(3)	6(4)		10(3)	2(1)	8(1)		2(1)			4(2)			3(2)
Hemiptera	1(1)	10(1)	3(2)	8(3)	8(4)	3(3)	6(1)	4(2)	3(3)	4(3)	2(2)			1(1)	1(1)
Neuroptera							1(1)					1(1)		1(1)	
Coleoptera	18(7)	11(6)	10(5)	18(7)	49(17)	34(13)	10(7)	2(1)	5(1)	2(2)		3(2)			
Lepdioptera	22(14)	31(15)	36(35)	35(15)	49(17)	34(13)	32(10)	22(7)	34(16)	7(6)	33(13)	52(14)	3(3)	31(16)	28(8)
Diptera															
-flies		2(2)		8(3)	88(8)	22(8)	8(2)	24(6)	3(3)	2(2)	17(7)	22(8)	3(2)	1(1)	2(2)
-mosquitos	1(1)	2(1)		17(7)	5(4)	5(2)	3(2)	11(2)		2(2)	24(8)	3(2)			1(1)
Hymenoptera															
-wasps				1(1)	5(4)		1(1)	2(1)	1(1)						
-bees	7(3)	7(6)	14(6)						2(1)			4(1)			
-ants								1(1)	1(1)	2(2)					

Table 3. Total numbers of insects collected at BP (numbers of species in parentheses)

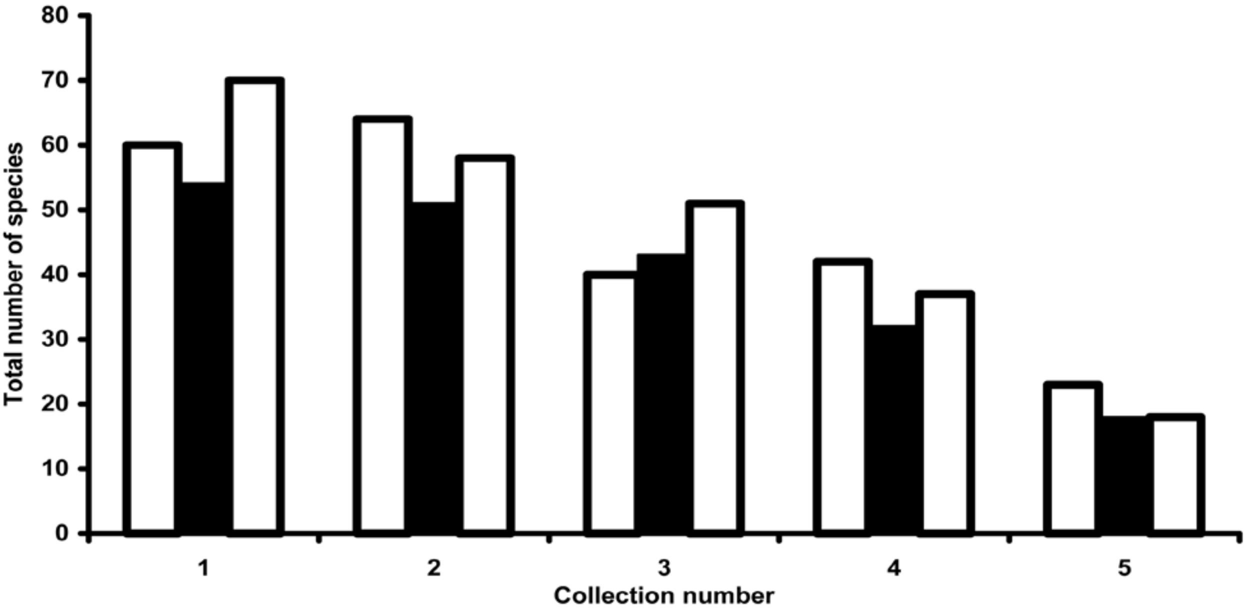
Insect order	Collection number and site														
	1 – 23th February			2 – 16th March			3 – 6th April			4 – 27th April			5 - 18th May		
	Site 1	2	3	Site 1	2	3	Site 1	2	3	Site 1	2	3	Site 1	2	3
Odontata		6(2)			2(1)							1(1)			
Blattodea	1(1)														
Mantodea															
Orthoptera			1(1)					1(1)	2(2)						
Hemiptera	8(5)	11(4)	37(7)	39(10)	26(5)	3(3)	25(6)	11(3)		12(7)	13(3)	1(1)	4(3)		
Neuroptera	1(1)	1(1)						1(1)			1(1)		1(1)		
Mecoptera	2(1)		2(1)										2(1)		
Coleoptera	7(5)	5(4)	23(8)	8(6)	3(2)		21(7)	5(5)		1(1)		2(2)			
Lepdioptera	26(15)	24(12)	36(12)	38(11)	44(15)	6(5)	32(14)	31(12)	52(14)	20(9)	14(7)	31(10)	23(9)	6(5)	7(5)
Diptera															
-flies	17(9)	11(8)	37(8)	64(12)	310(8)*	73(8)	2(1)	65(7)	22(9)	6(5)	87(6)	30(6)	3(2)	8(4)	8(4)
-mosquitos	23(2)	29(6)	27(2)	51(7)	38(6)	3(3)	17(3)	7(3)	1(1)	5(4)	3(2)	2(2)	4(2)	5(2)	1(1)
Hymenoptera															
-wasps															
-bees	4(3)		5(3)												
-ants							5(1)	3(2)		1(1)					

* > 250 of 1 species

Table 4. Total numbers of insects collected at Cab/ QE (numbers of species in parentheses)

Insect order	Collection number and site														
	1 – 25th February			2 – 18th March			3 – 8th April			4 – 29th April			5 - 16th May		
	Site 1	2	3	Site 1	2	3	Site 1	2	3	Site 1	2	3	Site 1	2	3
Odontata			3(1)												
Mantodea		40(1)	2(1)		9(1)										
Dermaptera		1(1)													
Orthoptera	1(1)	1(1)	1(1)			1(1)									
Hemiptera	8(5)	11(8)	10(6)	16(8)	15(8)	15(6)	2(1)	4(3)	15(8)	3(3)	9(3)	1(1)	1(1)	1(1)	
Neuroptera				1(1)			1(1)	9(3)	3(1)		3(1)				1(1)
Mecoptera			1(1)			1(1)									
Coleoptera		20(5)	5(3)	29(6)	15(3)	2(2)	3(3)	2(1)	1(1)	11(4)	5(2)				
Lepdioptera	15(12)	90(28)	70(34)	51(17)	97(17)	38(17)	40(12)	26(15)	28(10)	22(11)	38(14)	40(7)	6(5)	4(4)	11(3)
Diptera															
-flies		6(4)	78(10)	23(5)	28(11)	435(12)*	2(2)	8(10)	505(11)**	3(3)	18(7)	166(6)	13(5)	10(6)	8(2)
-mosquitos	2(1)	45(4)	64(4)	58(6)	74(6)	121(5)	1(1)	7(3)	59(8)	12(4)	4(2)	11(5)	12(4)	1(1)	146(2)
Hymenoptera															
-wasps					1(1)	1(1)			2(2)			1(1)	1(1)		
-bees															
-ants	2(2)	10(4)	9(4)	4(2)			1(1)		1(1)	1(1)	2(2)		1(1)		

* >400 of 1 species; ** 175 tipulid flies and >250 of 1 other species.



Collections were made on 23-25 February (1), 16-18 March (2), 6-8 April (3), 27-29 April (4) and 16-18 May (5). Data is presented for each collection time (left to right) as Lane Cove National Park (clear), Bicentennial Park (black) and Cabarita /Queen Elizabeth Parks (clear).

Figure 3. Total insect species collected at the light trap at the 3 locations.

For example (Table 2) on the 23rd of February 2001, at Lane Cove National Park, a total of 60 different insect taxa was caught at the light from the Orders of Odontata (1-Site 3), Isoptera (1-Sites 1 and 2), Mantodea (1-Site 3), Orthoptera (4-Site 3), Hemiptera (2-Site 3), Coleoptera (7-Site 1), Lepidoptera (35-Site 3), Diptera (3-Site 2), and Hymenoptera (6-Sites 2 or 3). These data are termed "Total Insect Taxa". This estimate of the biodiversity at each location was chosen in preference to determining the mean number of taxa from the three sites at each location for each sampling time (this was implicit in the original design for the trapping program which was to use three sites at each location). However, this method was also used and is presented as "Mean Insect Taxa", with the variation given as ± SD.

Significance differences were assessed by Students' t-test using Minitab statistical package (version 13) and significance was assigned when $p<0.05$.

Table 5. Total insect taxa trapped at each site for each sampling time (LCNP, Lane Cove National Park; BP, Bicentennial Park; Cabarita & Queen Elizabeth Parks).

Location	Site	Samples				
		23-25 Feb	16-18 March	6-8 April	26-28 April	18-20 May
LCNP	1	28	36	25	17	5
	2	35	58	20	30	19
	3	54	44	28	33	14
BP	1	42	46	32	27	16
	2	37	38	33	19	11
	3	42	19*	26	22	12
Cab/QE	1	21	46	21	26	17
	2	56	49	35	31	11
	3	65	46	42	20	8

*windy

Results

Climatic Conditions

The climatic conditions for the majority of the study were relatively clear with no rain experienced on trapping nights (Table 1). The temperatures followed seasonal patterns with warm evenings in February to mild conditions in March and April to cool-cold evenings in May. The cloud cover was generally scattered to absent with only two overcast evenings after rainy days. There was a full moon on 6th-8th April and a new moon appeared 26th-28th April; the remaining sampling nights were moonless. Most nights had light and variable wind after sunset; however, on April 17th there was a moderate south-west wind (Table 1). Overall, the fieldwork was accomplished under favourable collecting conditions.

Comparison of Species Diversity

The light trap attracted insects from about 50% of the main insect orders (Tables 2-4). The main taxa were Lepidoptera, Colepotera, Diptera, Hemiptera, Hymenoptera with minor contributions from Odontata, Mantodea, Neuroptera and Orthoptera.

Total Insect Species (Maxima)

Total number of species was similar among the three locations (Figure 2, Table 5). There was a tendency for BP to have slightly fewer species than the other two locations, but this was not significant (Figure 2). Total taxa ranged from 55-70 in February, declining steadily to around 20 species by the last sampling in May, but remained similar across the locations at each sampling time (Figure 2, Table 5). Moths provided the greatest diversity, comprising between 30 and 50% of the species taken (Tables 2-4). From a peak of 15-30 species in February, the number caught remained steady at 15 for the next three sampling times and declined to10 at the May sampling. The number of taxa from BP was most consistent over the four months (9-15 taxa) whereas declines in species for Cab/QE Park and LCNP were more dramatic (Figure 2., Table 5).

Mean Insect Species

The mean insect morphospecies for the total location/site/samples was 30$\pm$14 (LCNP), 28$\pm$ 11 (BP) and 33$\pm$17 (Cab/QEP). The mean insect morphospecies for each sampling time tended to be greatest from Cab/QE Park, but the data in Figure 3 indicate that once again, there were not large differences among locations. The mean number of species was around 40-47 for the first two samplings, except that the low value of 19 at Bicentennial Park on the 17th March was due to wind. This effect skewed the mean $\pm$ S.D to 34$\pm$11. Subsequently the mean numbers of species declined steadily to 12-13 by the 5th sampling in May. (Figure 3; Table 5).

Discussion

During the warmer months of this study the total number of insects attracted to the light was rarely less than 50 in a 30-minute session and the maximum exceeded 600 for Diptera and Lepidoptera alone. This is a considerable quantity and range considering that only night flying members of 50% of all insect Orders were targeted in this project. The great advantage of light traps is that for moths, there is "…no other trapping method that has proven so consistently successful in capturing larger numbers or a greater variety of species… It has become evident that, in addition to moths, a wide range of insect orders, genera and species are regularly attracted to light traps…" (Muirhead-Thomson 1991, p12). The efficiency of light traps in particular studies depends on a number of variables ranging from the site of the light trap itself to the climatic conditions. The light trap is more efficient than pheromone (chemical lures) or "sticky" traps (Thompson *et al.* 1987). Moths will deviate from their flight paths towards light if they are within 25m (McGeachie 1987), and the ability of UV lights to trap moths has been estimated at 50% of the flying population for the Cotton Bollworm Moth and 38% for the Cabbage Looper Moth (Hartstack *et al.* 1968).

The regular change in the lunar cycle presents an ecological variable for the fieldwork because moonlight diverts flying insects away from the UV light, thus compromising insect catches. On a night that has a full moon, the power of the 125 Watt UV light diminishes to the strength of moonlight at 30m, whereas on a moonless night the same light can theoretically attract insects from up to 500m (Bowden and Morris 1975). Results show that when the full moon was present (see Table 1) there was a substantial drop in the mean insect taxa and total insect taxa at LCNP on April 6th; the moon rose too late to cause interference on 7th-8th of April. The moon is one variable that has been shown to reduce the actual numbers of insects (Danthanasayana 1986), but climate, especially temperature, is also a factor affecting light trapping. As seen from all the data, insect catches decreased as the season changed and temperatures declined. Most studies agree that larger numbers of insects are caught after dusk in the presence of warmer air temperatures (Muirhead-Thomson 1991). Hence, the timing was appropriate for this investigation. Another climatic variable is the wind speed. Slight wind appears beneficial for insect trapping at light. Wind speeds of 1-2m/sec actually increased insect flight but higher wind speeds are detrimental (Douthwaite 1978; Tucker 1983; Morton *et al.* 1981). This may explain the lower insect catch at BP, Site 3, on the 17th April with the SW wind (Table 5).

Despite the possible influence of the above variables, the insect biodiversity among the three locations and sites was similar. Although lower numbers of insects were collected at BP, the biodiversity was similar among the three locations. From the similarity of the biodiversity data, there is no evidence that human usage of recreational areas decreases insect biodiversity. The location that had the most taxa diversity one week did not necessarily have the most the next week (*i.e.* the ranking of sites and locations varied throughout the study period; Figure 2, 3). This similarity in the numbers of insect taxa could have three principal explanations. Firstly, site factors may have been important. The similarity of the insect numbers may have been due to the lack of a control site completely devoid of human activity. Since all sites had evidence of some human activity, LCNP was chosen for undisturbed natural bushland. However there is human recreational activity at Sites 1 and 2 that could affect insect numbers, due to picnic areas and road construction. In addition, the Lane Cove River next to the two sites appeared quite polluted and a considerable amount of exotic weeds lined the river banks and surrounding areas. This could also affect insect biodiversity. The local ecosystem of BP has had considerable input (for the Olympics), and there is increasing human recreational activity that could impact on insect numbers. Cabarita Park was well-chosen for the heavy usage area. It is located next to the water and has considerable human impact from the car and bus traffic passage to the Ferry, for picnics and ball games. However, our sites were located near Queensland brushbox and eucalypts, with stands of native grasses amongst sandstone. The local ecosystem of QE Park is less heavily impacted by human activities. It is used more for sporting activities, is surrounded by main roads and is well maintained for its size. Unlike Cabarita Park, it does not have any public vehicular access into the park. Thus QE Park was rather similar to LCNP. Despite the obvious differences in usage, insect biodiversity was similar over all locations, and the three sites within each were only designed to obtain a more representative sample of the biodiversity.

The second main influence could be the insects themselves. Since light traps attract flying insects from approximately 50% of the extant insect orders, there is also a possibility that the greatest impact of human usage of parkland may be on those species not attracted to light. Many of these insects are flightless, and some, such as butterflies, are drastically affected by human activity as the larvae have very restricted food plants. Moth larvae on the other hand, have readily adapted to many exotic or introduced feed-plants (Common 1990), such that the presence of "weeds" and exotic grasses along Lane Cove River may actually favour moth biodiversity.

There may be factors influencing insect biodiversity apart from location and human usage. The major influence is the diverse, local vegetation at the site (M. Moulds, pers. comm. 2001). The similar levels of insect biodiversity at the three sites was considered most likely due to the proximity of feed-plants or food sources (land or aquatic) for insect larvae. All sites contained mixtures of native and introduced grasses (*e.g.* kangaroo grass, kikuyu, couch and prairie grasses) as well as native trees (eucalypts, acacias, turpentine, casuarinas). This would provide ample food for a wide variety of Australian insects adapted to native food-plants and grasses (especially members of Lepidoptera, Coleoptera and Hemiptera). The diversity of Diptera may reflect the ability of members of this order to cover large distances from nearby suburbia, and the presence of local water. This, in itself is an important outcome for the maintenance of insect biodiversity, providing planners with a rationale for maintaining stands of both trees and grasses. It also suggests that some portion of recreational areas should have restricted human traffic, if only to provide a sheltered area from which flying insects can emigrate.

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