
Spatial variability in the pollen count in Sydney, Australia: can one sampling site accurately reflect the pollen count for a region?

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Background: There is increasing interest in the daily pollen count, with pollen-sensitive individuals using it to determine medication use and researchers relying on it for commencing clinical drug trials and assessing drug efficacy according to allergen exposure. Counts are often expressed qualitatively as low, medium, and high, and often only 1 pollen trap is used for an entire region.

Objectives: To examine the spatial variability in the pollen count in Sydney, Australia, and to compare discrepancies among low-, medium-, and high-count days at 3 sites separated by a maximum of 30 km.

Methods: Three sites in western Sydney were sampled using Burkard traps. Data from the 3 sites were used to compare vegetation differences, possible effects of some meteorological parameters, and discrepancies among sites in low-, medium-, and high-count days.

Results: Total pollen counts during the spring months were 14,382 grains/m³ at Homebush, 11,584 grains/m³ at Eastern Creek, and 9,269 grains/m³ at Nepean. The only significant correlation between differences in meteorological parameters and differences in pollen counts was the Homebush-Nepean differences in rainfall and pollen counts. Comparison between low- and high-count days among the 3 sites revealed a discordance rate of 8% to 17%.

Conclusions: For informing the public about pollen counts, the count from 1 trap is a reasonable estimation in a 30-km region; however, the discrepancies among 3 trap sites would have a significant impact on the performance of a clinical trial where enrollment was determined by a low or high count. Therefore, for clinical studies, data collection must be local and applicable to the study population.

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INTRODUCTION

Interest in the daily pollen count has increased dramatically during the past few years. Media reporting of the pollen count assists the many people with pollen sensitivity in managing their symptoms by initiating medical treatment at the first sign of rising pollen counts. Data used for community broadcasts and clinical trials are often stated as being low, medium, and high rather than as absolute values. Clinical researchers who conduct drug trials and other allergy studies rely on such pollen counts for determining study commencement and in data analysis (assessing drug efficacy according to allergen exposure). In this circumstance, the results from a single rooftop sampler are often applied to a whole city, although there may be very significant differences in vegetation and even in meteorological parameters among regions in a city. Furthermore, there is lack of uniformity among those reporting pollen studies, so it is difficult to compare findings from various investigators.¹

Many factors influence pollen concentration at various points, and these have been the subject of an excellent and

thorough review.² Pollen recovery across a region is most similar when pollen is transported from distant sources rather than from vegetation in close proximity to a particular trap. Although spatial variability in the pollen count has been examined in a few cities,^{3,4} it has never been studied in Sydney, Australia's largest city, with a population of almost 5 million people. To investigate regional pollen variability in Sydney, we sampled the western region of the city during the 1999 pollen season. We compared pollen counts at each of 3 locations, examining possible effects of some meteorological variables and differences in regional vegetation to determine which of these exerted a significant influence on pollen recovery from the 3 traps. The main objectives of this study were to examine the relevance of pollen counts for use in clinical trials and for media broadcasts by examining spatial variability in a large region of Sydney and to examine discrepancies among the sites when counts were described as high, medium, or low.

METHODS

Pollen Counts

Three sites were chosen for the study in the western region of Australia's largest city, Sydney. Sydney is a coastal city bordered on the west by a mountain range and on the north and south by extensive national parkland. The 3 sites used were Homebush, Eastern Creek, and Nepean (Fig 1). A

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Scale 0 _____ 5 km

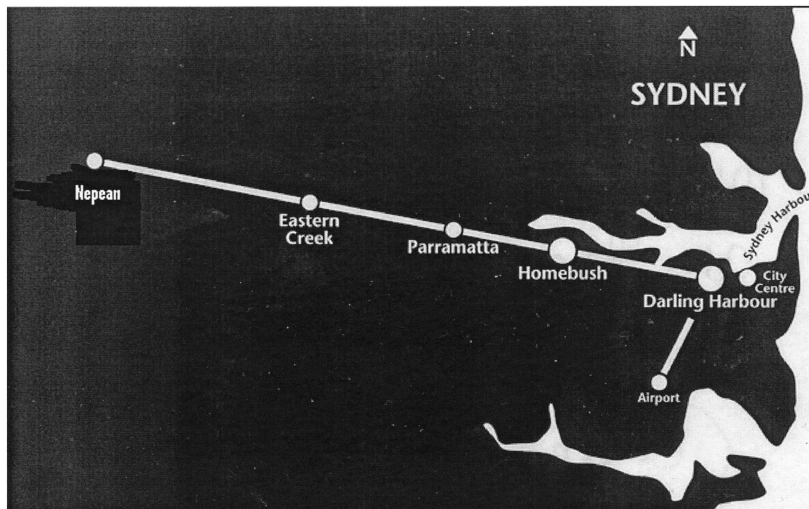


Figure 1. Locations of the pollen traps in Sydney.

distance of approximately 30 km separates the first and third sites.

Burkard 7-day volumetric spore traps (Burkard Manufacturing Co, Rickmanworth, England) were run from August (late winter) to November (late spring) of 1999. The 3 Burkard traps were located on rooftops 15 m above ground. Each trap had an unobstructed position on the rooftop. The traps were calibrated before installation and were run off a main power source.

The drums and slides were prepared as described previously⁵ and were read by experienced pollen counters. A daily 24-hour pollen count was provided for each site in pollen grains per cubic meter. Evaluation of diurnal variability was not attempted.

Classification of Low, Medium, and High Pollen Counts

There is no universal agreement on how low, medium, and high pollen counts should be defined. In a recent international clinical drug trial, total counts greater than 30 grains/m³ were defined as high, with counts of 30 grains/m³ or less defined as low. In a Scottish Centre for Pollen Studies information leaflet,⁶ low is defined as 50 grains/m³ or less, medium as 51 to 100 grains/m³, and high as greater than 100 grains/m³. On the other hand, Burge⁷ suggests that low, medium, and high be defined mathematically using data collected during several years. By constructing a box plot that represents the total count for a particular species at a single site, the various percentiles could be defined. She suggests that descriptors such as low, medium, and high be expressed according to whether the count is below the 50th percentile (low), between the 50th and 75th percentiles (medium), and between the 75th and 99th percentiles (high). These definitions will yield different figures for different species in a given area. For the present study, the Scottish recommendations were followed, and low (≤ 50 grains/m³), medium (51–100 grains/m³), and high (> 100 grains/m³) were used to categorize pollen levels.

Meteorological Data

Meteorological data from weather stations close to each pollen trap were obtained from the Bureau of Meteorology in Sydney. Variables available to us were daily minimum and maximum temperature and daily rainfall.

Vegetation Distribution

For each site, a tree species distribution map around the pollen trap is shown because tree pollen exhibited the greatest variability (Fig 2). Each map was devised from direct observation of the area, site landscaping plans (very detailed, since Homebush was the Sydney 2000 Olympic venue), and horticultural notes. The major species at each site are *Cupressus*, *Casuarina*, *Eucalyptus*, and, at the Homebush site, *Platanus*. Homebush and Nepean are situated close to residential areas with a wide range of introduced European and native Australian (*Acacia* and *Grevillea*) tree species and grasses (kikuyu [*Pennisetum clandestinum*], buffalo [*Stenotaphium secundatum*], and Bermuda [*Cynodon dactylon*]). In addition, all 3 areas are close to parks and bushland with large areas of roadside grasses (perennial rye [*Lolium perenne*] and *Paspalum*) and weeds (plantain [*Plantago lanceolata*] and clover [*Trifolium repens*]). The Eastern Creek site is situated in a business park that has been recently developed from bushland.

Statistical Analysis

Data were summarized using either means and SDs or, in the case of skewed data, medians and interquartile ranges (box plots). Spearman rank correlation coefficients were used to test for associations between differences in temperature and rainfall among sites.

RESULTS

Absolute Counts

Total pollen counts for the season were 14,382 grains/m³ at Homebush, 11,584 grains/m³ at Eastern Creek, and 9,269

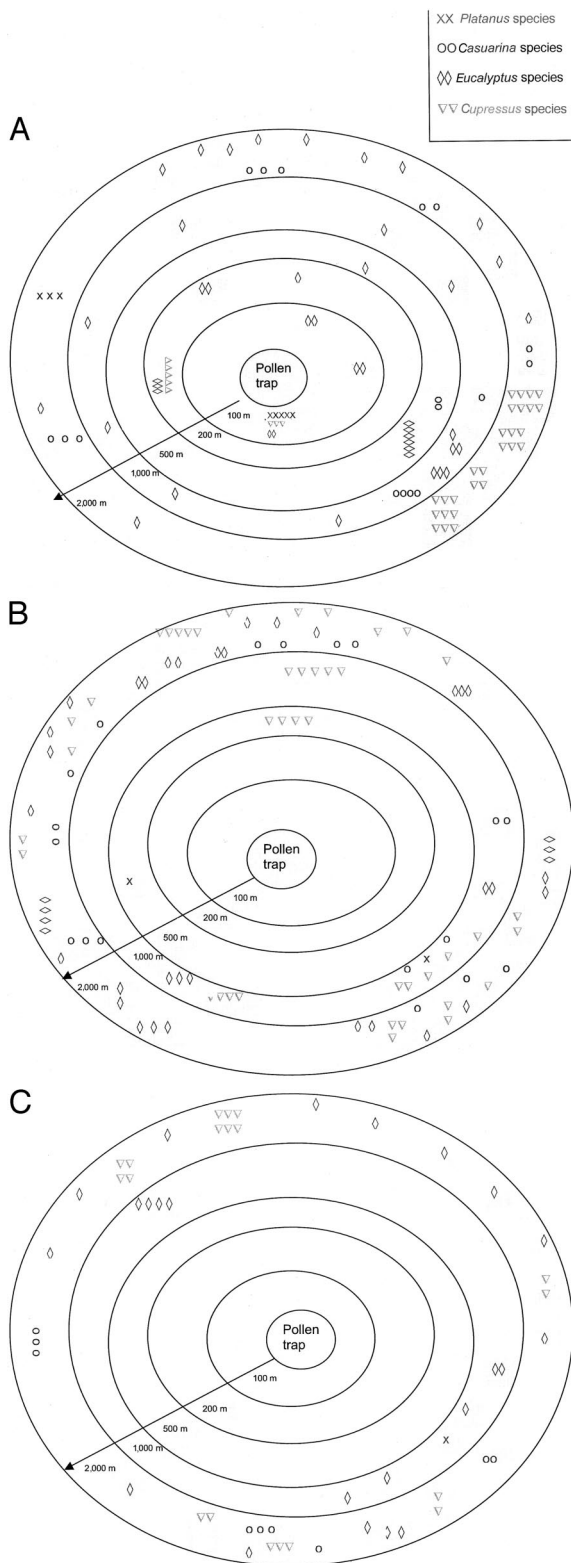


Figure 2. Vegetation species distribution at the pollen trap sites in Homebush (A), Eastern Creek (B), and Nepean (C).

grains/m³ at Nepean). With the *Platanus* count excluded, the Homebush count was 9,900.

Meteorological Differences

Differences in daily pollen counts among the sites were not significantly associated with differences in daily temperature (either mean or minimum/maximum) or with differences in rainfall. The only exception was the significant correlation between Homebush and Nepean pollen count differences and the difference in rainfall ($P = .003$) at these sites. The higher rainfall at the Nepean site was reflected in a lower pollen count (correlation coefficient = 0.292). The comparison between temperature and rainfall at the 3 sites is given in Table 1.

Variability in Vegetation

The tree species distribution maps (Fig 2) demonstrate quantitative differences. For example, within the first 100 m of the Homebush pollen trap there is a large planting of *Platanus*, and this is reflected in the high *Platanus* pollen count at this site but not at the other 2 sites (Fig 3). The weekly distribution of Poaceae (Fig 4) and *Cupressus* (Fig 5) throughout the season and the total weekly pollen count (Fig 6) are also shown for each site. Figure 7 illustrates the mean daily pollen count by major pollen types at each site.

Comparison of Low, Medium, and High Pollen Count Days

The division of days into low, medium, and high counts has a significant impact on the conduct of clinical trials in allergic disease. Enrollment into a trial and when to use medication are often determined by the qualitative count. From our data, the percentage of days on which one site recorded low pollen counts and another recorded high pollen counts was 8% (9 of 110 days) for Eastern Creek vs Nepean, 13% (13 of 99 days) for Homebush vs Nepean, and 17% (21 of 124 days) for Homebush vs Eastern Creek.

DISCUSSION

There are a few published studies that investigate the relationship between pollen counts from traps in the same city or at relatively short distances apart. Emberlin and Norris-Hill³ examined spatial variability of pollen deposition in North London, England, in a 5 × 5-km area. *Platanus* deposition showed the greatest variability, with poor correlation between counts over the years. *Betula* and Poaceae were similar at all locations because of transport from distant sources, in contrast to *Platanus*, which was derived from point sources scattered throughout the area.

Frenz et al⁴ reported on results obtained from pollen counts performed at 2 locations in St. Paul, MN. Rotorod samplers were installed on the rooftops of 2 buildings 5.6 km apart. The total number of pollen grains recovered from the 2 samplers was nearly equivalent, although daily and monthly differences were seen. Differences were most pronounced for counts greater than 100 grains/m³.

One of the strengths of the present study was the availability of meteorological data in close proximity to the 3 traps.

Table 1. Spearman Rank Correlation between Site Differences in Pollen Count and Differences in Temperature and Rainfall

	Temperature difference			Rainfall difference
	Mean	Maximum	Minimum	
EC-Nepean total pollen				
Correlation coefficient	−0.51	−0.43	−0.115	−0.1
P value (2-tailed)	.60	.66	.24	.92
Pollen collection days, No.	106	106	106	110
HB-Nepean total pollen				
Correlation coefficient	−0.034	−0.041	0.175	−0.292
P value (2-tailed)	.75	.70	.09	.003
Pollen collection days, No.	93	93	94	99
HB-EC total pollen				
Correlation coefficient	−0.12	−0.12	0.108	0.013
P value (2-tailed)	.19	.19	.24	.89
Pollen collection days, No.	119	119	120	124

Abbreviations: EC, Eastern Creek; HB, Homebush.

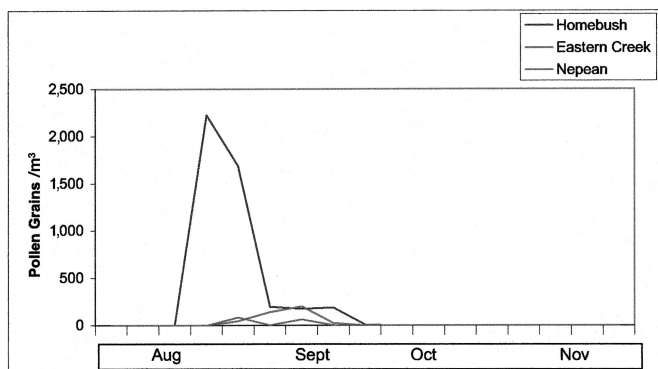
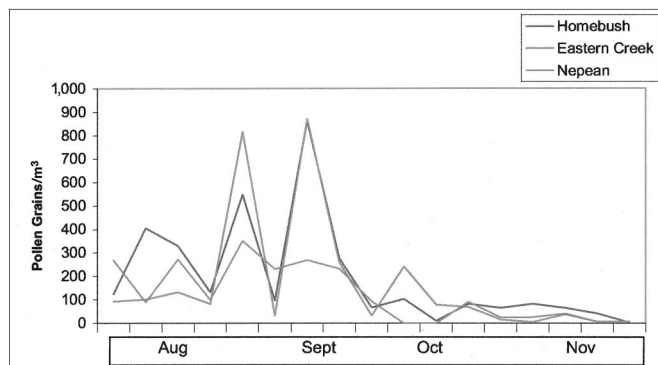
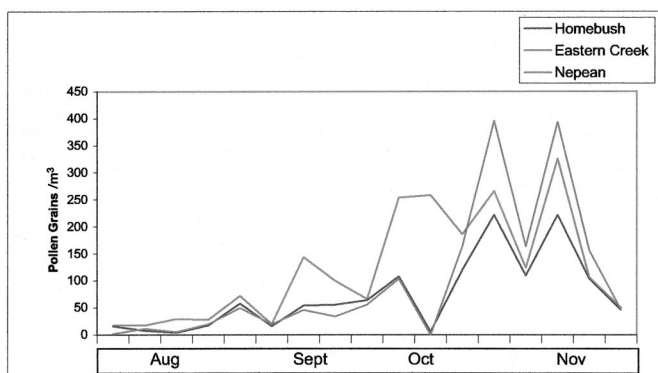

Figure 3. Weekly *Platanus* pollen count at each site.

Figure 5. Weekly *Cupressus* pollen count at each site.


Figure 4. Weekly Poaceae pollen count at each site.

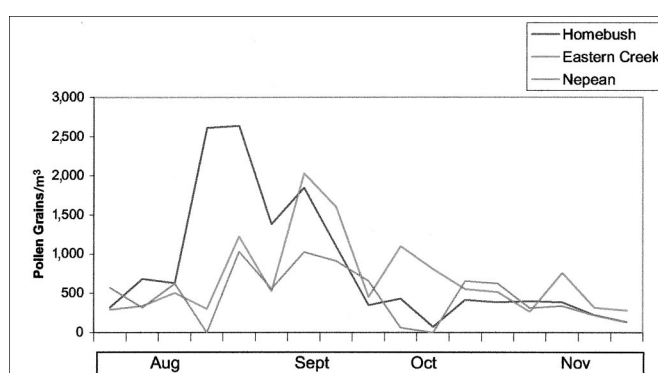


Figure 6. Weekly total pollen count at each site.

Meteorological differences at the 3 sites had minimal influence on the differences in counts. Total pollen recovery was similar at the 3 sites once the heavy influence of *Platanus* at the Homebush site was discounted. Local vegetation seemed to account for the most important differences, with the vari-

ation in *Platanus* being the best example of the impact of local influences.

The transformation of quantitative pollen counts into descriptors such as low, medium, and high poses several difficulties for those with a clinical interest in pollen levels.

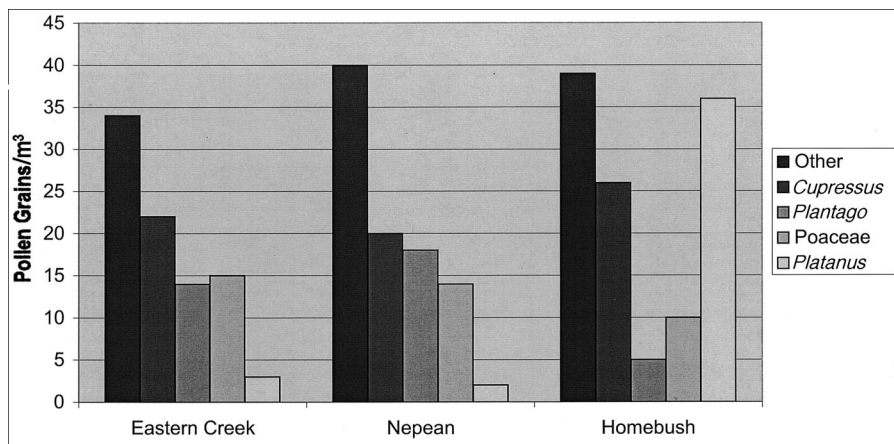


Figure 7. Mean daily pollen count by pollen type and site.

Although low, medium, and high counts can be defined mathematically when several years' pollen data exist, as proposed by Burge,⁷ the relationship of these levels to the level needed to provoke symptoms in pollen-allergic patients is questionable. For indoor allergens, such as house dust mite and cat, some data exist on the actual level of allergen required first to sensitize an individual and second to trigger symptoms in a previously sensitized person. Such levels are unknown for pollen. The pollen count records the number of pollen grains, which probably does not reflect the total allergen load for that particular pollen because at least some pollen allergen exists in submicronic particles and may even be in a dissolved form but still available for inhalation. The inhaled pollen dose required to produce respiratory allergic symptoms probably varies widely and may differ for various plant species. Furthermore, the threshold at which an individual reacts is modified by recent exposure history. Decreasing amounts of pollen are required to elicit symptoms as the pollen season progresses, a phenomenon known as "priming."⁸ In other words, little is known about the dose-response relationship for pollen sensitivity.

The data that exist have been derived from clinical trials in which enrolled subjects kept symptom diaries, and symptom scores were related to pollen counts. In a study of British subjects,⁹ ambient grass pollen levels of 20 grains/m³ were associated with the onset of symptoms. Individual sensitivity will also influence the severity of symptoms. In highly sensitive individuals, symptoms occur with counts of 15 to 75 grains/m³ per 24 hours, whereas levels up to 10 times higher than this may be required for less sensitive individuals.¹⁰

Viander and Koivikko¹¹ studied specific immunotherapy efficacy in a group of birch pollen-allergic patients. Special interest was focused on the amount of pollen required to precipitate symptoms in treated and untreated individuals. At the onset of the season, the appearance of symptoms depended on the rising pollen count, with approximately 90% of all patients reporting symptoms when the count exceeded 80 grains/m³. The appearance of symptoms at pollen counts of

less than 30 grains/m³ in the early season was associated with high nasal sensitivity.

With the popularity of the use of low, medium, and high categories for clinical trials and the pressure to use only 1 trap for each study site, the important question is whether 1 trap can accurately reflect regional differences in a geographic area covered by subject enrollment. Important discrepancies occurred 8% to 17% of the time, and this would have a significant impact on the conduct of the trial.

CONCLUSION

In the present study, significant differences occurred in the qualitative and quantitative data collected by 3 pollen traps in a 30-km radius in western Sydney. Qualitative differences reflect local vegetation rather than the weather variables investigated. For the purposes of informing the public about pollen levels, the count reported from 1 trap is probably a reasonable estimation of the prevailing situation. However, the situation is very different when these data are used for the conduct of clinical trials. Discrepancies found among the 3 traps in a 30-km radius would have had a significant impact on a clinical trial situation. Therefore, researchers who perform clinical trials that depend on pollen counts must ensure that data collection is local and applicable to the subject group being studied.

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