

Effects of Stand Structural Characteristics on the Microclimate of Bang Kachao Green Space : The Best Urban Oasis of Asia

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Abstract

Bang Kachao is a large urban green space, close to Bangkok and important area for recreation, biodiversity conservation, eco-learning and ameliorate microclimate in urban area. Development from Bangkok and Samut Prakan province is pressured and changed this green space to be urbanization. The objectives of this research project were to study and compare the stand structural characteristics and microclimate in terms of air temperature in Bang Kachao Green Space. Stand density with three classes, as high, moderate and low, were treatments. Three replicate sample plots of 0.25 ha (50 x 50 m) were randomly established in each stand density. All trees were tagged and stand structural characteristics measured. Microclimate stations, at 1.5 meter above the ground, at the center of each sample plot recorded air temperature and relative humidity at 10 minute time intervals for one year. Preliminary results of stand structural characteristics showed that the number of tree species and number of families of trees in each plot ranged from 2 to 26, and 2 to 17, respectively. Stand density and total basal area varied with stand density class and were highest in stand density class I (high density), moderate in stand density class II (moderate density) and lowest in stand density class III (low density). The average annual mean temperature of stand density classes I, II, III and built-up areas were 27.7, 28.2, 29.2 and 29.4 °C, respectively. Differences in annual mean temperature in the stand density classes compared with the built-up area were 1.74, 1.23 and 0.27 °C, respectively. Monthly mean and maximum temperatures tended to decrease in stands of high density and basal area. These results may be useful for future urban planning and management of urban green spaces to ameliorate urban microclimate.

Keywords: stand structural characteristics, microclimate, urban green space, Bang Kachao

Introduction

Bang Kachao (Figure 1) is a large urban green space, close to Bangkok, covering an area of about 1,891 ha. Time Magazine named the Bang Kachao Green Space as “**the best urban oasis of Asia**” in May 2006. An important date in the recent history of Bang Kachao is 14 September 1977. That day the council of ministers agreed to preserve Bang Kachao as a green space and develop it as a “**garden in the city**”. A strict local planning and building code was introduced and the Office of Natural Resources and Environment Policy and Planning (ONEP) embarked on a land acquisition program that eventually resulted in the acquisition of about 204 ha. Since 2005, these lands have been under the care of the Royal Forest Department (RFD). In recent years, due to improved access, development pressure on the area has mounted, land prices have tripled and the orchard and water body areas

have decreased due to increased urbanisation. The big questions that arise are: “how to protect Bangkok’s last green lung from urban development?” and “how to conserve and help Bang Kachao to remain predominantly green, in the near as well as in the distant future?”

This research project investigated stand structural characteristics and microclimate in term of air temperature and relative humidity of Bang Kachao Green Space. The objectives of this research were to study and compare stand structural characteristics of Bang Kachao green space and affect on the microclimate in term of air temperature and relative humidity. The results from this research may be useful for the urban planning and management urban green space to ameliorate urban microclimate in the future.

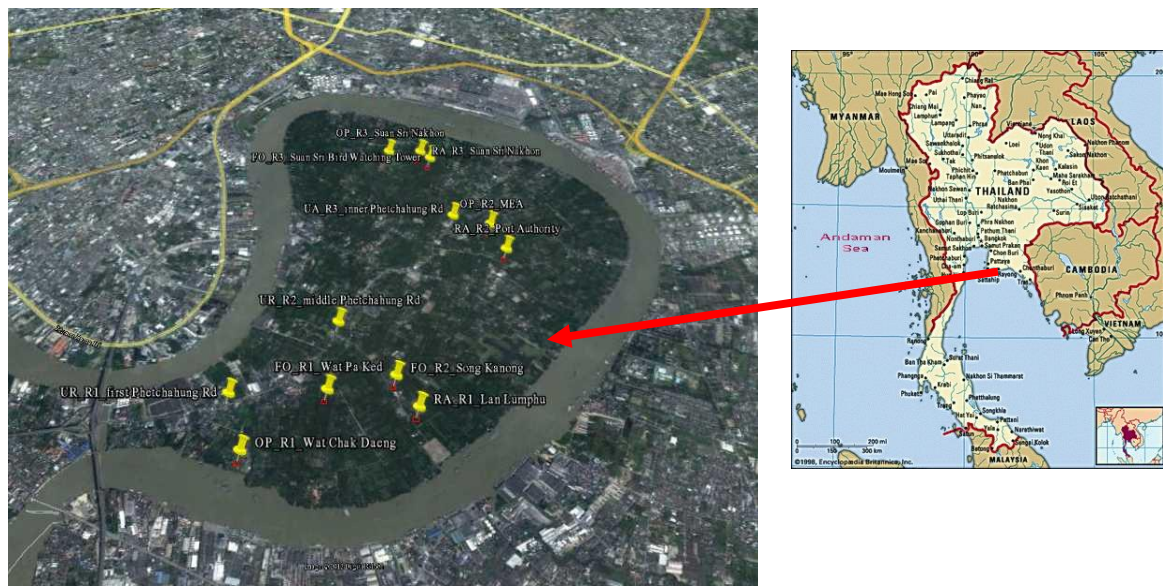


Figure 1. Distribution of sample plots and shape of Bang Kachao Green Space, Phra Pradaeng District, Samut Prakan Province, Thailand

Source : Google (2012)

Methodology

Three permanent sample plots of 0.25 ha (50 x 50 m) were randomly established in each class of stand density as high, moderate and low and used the built-up area along the main road as the control sites (Figure 1). Each permanent plot of 0.25 ha was divided into 25 subplots (10 x10 meters). All trees (DBH> 4.5 cm) were tagged and measured in February 2012. Diameter at breast height (DBH) was measured with a diameter tape and total stem height (H) and height to the lowest living branch (Hb) were measured using a VERTEX Laser VL400. At 1.5 m, air temperature and relative humidity were recorded at 10 minute intervals for one year using a data logger HOBO Pro V2 in the center of each plot. Stand data were used to calculate and analyze stand structural characteristics as DBH, height, relative density (RD), relative frequency (RF), relative dominance (RDo), importance value index (IVI), and species diversity by Shannon-Wiener’s index (Shannon and Weaver, 1949).

Results and Discussion

Stand characteristics

Stand density (DBH > 4.5 cm) was high in class I (stand 1: D1S1, stand 2:D1S2, stand 3:D1S3), intermediate in class II (stand 4:D2S1, stand 5:D2S2, stand 6:D2S3) and low in class III (stand 7:D3S1, stand 8:D3S2, stand 9:D3S3), being 1,268-716, 892-820, and 980-104 trees/ha, respectively (Table 1). Total basal area was similar to stand density, high in class I (91.10-58.44 m²/ha), intermediate in class II (52.94-40.34 m²/ha) and low in class III (38.31-9.28 m²/ha) (Table 1). Average DBH ranged from 8.20 – 24.68 cm, and was highest in stand 9 and lowest in stand 7. Average stand height ranged from 5.03-8.54 m, being highest in stand 1 and lowest in stand 7. The contribution of each species to the above stand attributes are given in Table 2. Species diversity evaluated by Shannon-Wiener's (SW) index ranged from 0.43 to 2.59. Stand 6 had the highest SW index (2.59) and the lowest was in stand 9 (0.43).

Table 1 Stand characteristics of Bang Kachao Green Space, Samut Prakan Province

Stand parameter	Stands of Bang Kachao Green Space								
	Class I: high density			Class II: moderate density			Class III: low density		
	Stand 1 (D1S1)	Stand 2 (D1S2)	Stand 3 (D1S3)	Stand 4 (D2S1)	Stand 5 (D2S2)	Stand 6 (D2S3)	Stand 7 (D3S1)	Stand 8 (D3S2)	Stand 9 (D3S3)
1. Plot size, (ha)	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
2. Stand density, (trees/ha)	1,268	988	716	820	840	892	360	980	104
3. Number of species	15	24	18	17	15	26	13	11	2
4. Number of families	10	15	13	15	11	17	8	8	2
5. Total basal area, (m ² /ha)	91.10	74.42	58.44	49.97	52.94	40.34	9.28	38.31	20.89
6. Average DBH, (cm)	12.94	13.25	13.24	11.84	12.87	9.66	8.20	9.58	24.68
7. Average Height, (m)	8.40	8.19	8.54	5.14	7.58	6.67	5.03	6.63	7.53
8. Shannon-Wiener's H*	1.78	2.39	2.12	1.57	1.88	2.59	1.86	1.39	0.43

Remark : D1S1 = high density stand 1 (Suan pha ked urban forest)
 D1S2 = high density stand 2 (Port Authority of Thailand)
 D1S3 = high density stand 3 (Sri Nakhon Khuenkhan Park)
 D2S1 = moderate density stand 1 (Homegarden agroforestry by local people)
 D2S2 = moderate density stand 2 (Lan Lum Phoo)
 D2S3 = moderate density stand 3 (Bird watching tower, Sri Nakhon Khuenkhan Park)
 D3S1 = low density stand 1 (Wat Chak Daeng Park)
 D3S2 = low density stand 2 (MEA Agroforestry plot)
 D3S3 = low density stand 3 (Turf grass at Sri Nakhon Khuenkhan Park)

Microclimate in Bang Kachao Green Space

The average annual mean temperatures of stand density classes I, II and III and the built-up area were 27.67, 28.19, 29.15 and 29.41 °C, respectively (Table 2). The reduction in annual mean temperatures in forest stands compared with the built-up area were 1.74, 1.23 and 0.27 °C in stand density class I, II and III, respectively. The maximum temperatures of stand density classes I, II and III and the built-up area were 34.66, 37.03, 39.82 and 38.41 °C, respectively (Table 3). Monthly mean and maximum temperatures were lowest in stands of high density and increased in stands of low density (Figure 2 and 3). In contrast, the stand density classes I, II and III and the built-up area were not showed the difference trend on the minimum temperature (Table 4 and Figure 4).

Table 2 Monthly mean temperature in various classes of stand density in Bang Kachao Green Space, Samut Prakan Province

Month (Year 2012)	Monthly Mean Temperature ($^{\circ}\text{C}$)			
	High density	Moderate density	Low density	Built-up area
Jan.	26.39	26.73	27.55	28.05
Feb.	27.41	28.04	28.84	29.29
Mar.	28.89	29.31	30.23	30.57
Apr.	29.94	30.44	31.31	31.52
May	29.12	29.64	30.53	30.48
Jun.	28.12	28.68	29.76	29.83
Jul.	28.12	28.68	29.76	29.83
Aug.	27.24	27.78	28.77	28.83
Sep.	26.49	27.11	28.08	28.10
Oct.	26.89	27.44	28.68	28.91
Nov.	26.82	27.32	28.19	28.69
Dec.	26.64	27.07	28.09	28.87
Average	27.67	28.19	29.15	29.41

These results showed that the high stand density of urban green space affected on mean air temperature and maximum temperature. These results may be useful for urban green space planning and management for ameliorate urban microclimate in term of air temperature in the future.

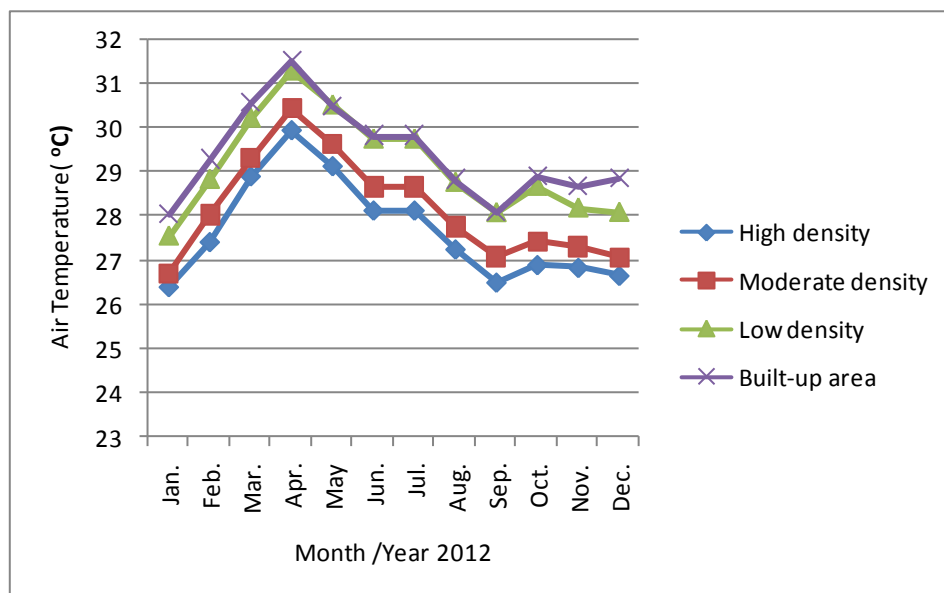


Figure 2 Monthly mean temperature ($^{\circ}\text{C}$) in various stand density classes of Bang Kachao Green Space, Samut Prakan Province.

Table 3 Maximum temperature in various stand density classes of Bang Kachao Green Space, Samut Prakan Province

Month (Year 2012)	Maximum Temperature ($^{\circ}\text{C}$)			
	High density	Moderate density	Low density	Built-up area
Jan.	33.44	35.43	38.60	35.95
Feb.	33.62	36.92	38.92	37.10
Mar.	35.75	38.06	40.85	38.90
Apr.	38.71	40.48	42.01	40.35
May	38.29	40.37	41.58	39.47
Jun.	33.92	36.34	38.49	37.29
Jul.	33.63	35.48	38.04	36.97
Aug.	34.53	36.21	37.98	37.72
Sep.	33.04	35.51	37.95	38.12
Oct.	33.83	36.43	41.49	40.30
Nov.	33.55	36.37	40.94	39.02
Dec.	33.64	36.72	41.06	39.76
Average	34.66	37.03	39.82	38.41

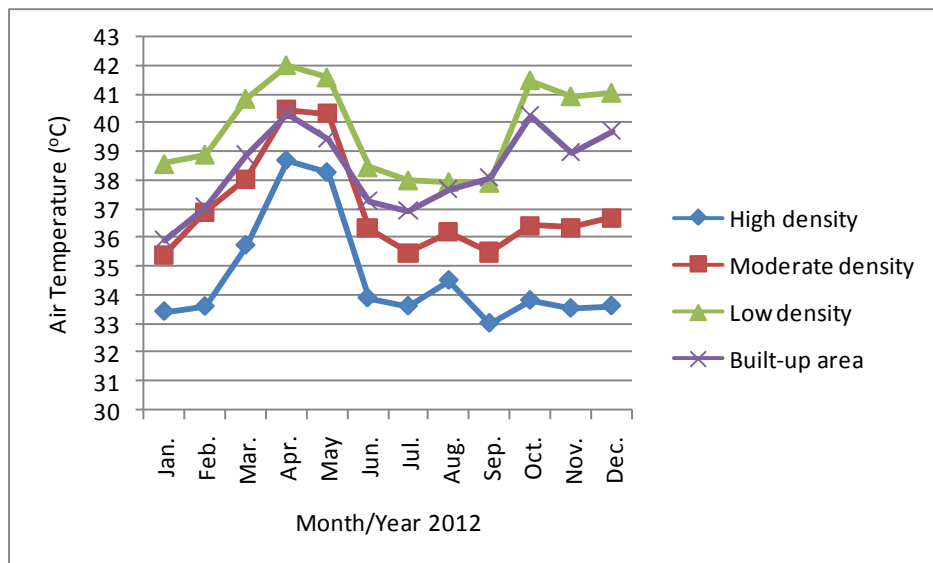


Figure 3 Maximum temperature ($^{\circ}\text{C}$) in various stand density classes of Bang Kachao Green Space, Samut Prakan Province.

Table 4 Minimum temperature in various stand density classes of Bang Kachao Green Space, Samut Prakan Province

Month (Year 2012)	Minimum Temperature ($^{\circ}\text{C}$)			
	High density	Moderate density	Low density	Built-up area
Jan.	19.55	19.08	18.59	20.24
Feb.	21.21	20.80	20.45	21.84
Mar.	22.90	22.37	22.58	23.25
Apr.	22.73	22.92	22.53	23.57
May	23.46	23.36	23.26	23.68
Jun.	23.49	23.49	23.38	23.73
Jul.	23.45	23.41	23.28	23.50
Aug.	22.74	22.88	23.33	23.15
Sep.	23.23	23.29	23.28	23.20
Oct.	23.03	23.09	22.90	23.08
Nov.	23.21	23.23	23.05	23.21
Dec.	20.03	19.84	19.51	20.70
Average	22.42	22.31	22.18	22.76

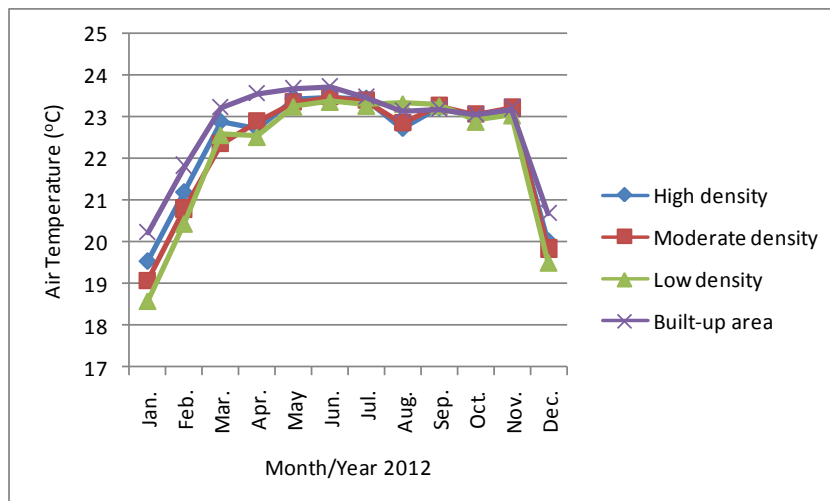


Figure 4 Minimum temperature ($^{\circ}\text{C}$) in various stand density classes of Bang Kachao Green Space, Samut Prakan Province

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