

TREE SPECIES COMPOSITION AND CONFIGURATION BASED ON
SQUIRREL BEHAVIOUR PATTERN IN SELECTED MALAYSIAN URBAN
PARKS

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DEDICATION

This thesis is dedicated to:

Mak and Abah

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In the Name of Allah, the Most Beneficent, the Most Merciful.

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ABSTRACT

In Malaysian urban parks, observing wildlife activity, particularly squirrels, is not a popular recreational activity among their users. This is due to the lack of attention being placed in the planning and design stage of the park in order to create good quality wildlife habitats which meet their ecological needs, particularly in urban parks. As such, this study aims to discover the tree species composition and configuration which influence the squirrels' activities and behaviour and consequently encourage squirrel-observing as a recreational activity. The three selected urban parks represent the northern, central and southern regions of Peninsular Malaysia where plantain squirrels can be found in abundance. The parks are the Taiping Lake Gardens, Taiping Perak, the Hutan Bandar, Johor Bahru and the Botanical Garden, Putrajaya. The software ERDAS IMAGINE 2014 was used to classify the land use features in each park. This is an essential tool used for extracting quantitative information from remotely-sensed image data. High resolution images of all three parks were obtained from Google Earth 2016. Each individual tree in which the plantain squirrels were sighted was plotted on GIS database using ArcGIS 10.0. Direct observations and focal animal sampling, with the help of binoculars, digital camera and activity check sheets were used to record the activities during the most active period for the squirrels, namely early in the morning and late evening. A total of four plots, with fifty-meter diameter for each park, were established based on the most squirrels sighted during the preliminary study. The relationship between the squirrels' behaviour and the tree characteristics was analysed with Chi-Square independent test in SPSS ver. 23. The findings revealed that plantain squirrels were strictly diurnal species with their peak activity during the early morning and late evening. Trees were mostly used for food sources as plantain squirrels mainly consume fruits. In terms of tree composition, native species were more dominant than non-native ones. Clustered tree configurations that exhibited connected canopies dominated all observation plots. Tree species which produced fruits all year round were widely planted in all these parks. Plantains frequently used the upper double vertical space which is in the middle and upper storey (5m-10 and 10-15m), for foraging and feeding where fruits were found in abundance. Hence, travelling activities were also mostly seen in the same storey as this activity was mainly related with looking for food source areas. In conclusion, this research allows park planners and designers to understand that the composition of trees and its configuration should be in accordance to the squirrels' ecological requirements. Therefore, this study reveals the fundamental factors for designing urban parks which will be able to offer squirrel-observation activities among Malaysian park users.

ABSTRAK

Aktiviti pemerhatian haiwan seperti tupai dalam kalangan pengunjung taman-taman bandar di Malaysia masih kurang popular. Ia disebabkan oleh kekurangan perhatian yang diberikan semasa peringkat perancangan dan reka bentuk taman dalam mewujudkan habitat haiwan yang menepati keperluan ekologi haiwan-haiwan tersebut. Oleh itu, kajian ini bertujuan untuk mengkaji komposisi dan konfigurasi spesis pokok yang mempengaruhi aktiviti serta tingkah laku tupai yang dapat menyokong aktiviti rekreasi pemerhatian tupai. Tiga taman bandar yang terpilih mewakili kawasan utara, tengah dan selatan Semenanjung Malaysia, tempat spesis tupai plantain banyak ditemui. Taman-taman tersebut ialah Taiping Lake Gardens, Taiping, Perak; Hutan Bandar, Johor Bahru; dan Taman Botani, Putrajaya. Perisian ERDAS IMAGINE 2014 digunakan untuk mengklasifikasikan ciri-ciri guna tanah di setiap taman. Ia mengekstrak maklumat kuantitatif daripada data imej yang diperolehi daripada data 'remote sensing'. Imej resolusi tinggi daripada ketiga-tiga taman itu diperolehi dari Google Earth 2016. Setiap pokok yang terlihat individu tupai di dalamnya, diplot dan direkod dalam pangkalan data GIS dengan menggunakan ArcGIS 10.0. Pemerhatian secara langsung dan pensampelan haiwan tumpuan dengan bantuan teropong, kamera digital dan senarai semak digunakan untuk merekodkan aktiviti-aktiviti tupai pada waktu paling aktif iaitu pada awal pagi dan lewat petang. Empat plot pemerhatian, dengan diameter lima puluh meter untuk setiap taman, telah dibentuk berdasarkan frekuensi individu tupai yang paling banyak dilihat semasa kajian awalan. Hubungan antara tingkah laku tupai dan ciri-ciri pokok dianalisis dengan ujian bebas Chi-Square dalam SPSS ver. 23. Penemuan menunjukkan tupai plantain ialah spesies diurnal dengan aktiviti puncak mereka pada awal pagi dan lewat petang. Pokok berbuah ialah sumber makanan utama. Komposisi pokok yang terdiri daripada spesis tempatan adalah lebih dominan daripada spesis bukan tempatan. Konfigurasi berkelompok dengan silara pokok yang saling bertaut mendominasi semua plot pemerhatian. Spesies tempatan yang berbuah sepanjang tahun ditanam secara meluas di dalam semua taman. Plantain juga kerap menggunakan dua ruang aras menegak pokok untuk aktiviti makan iaitu pada aras tengah dan atas (5m-10 dan 10-15m) kerana terdapat lebih banyak makanan di sini berbanding pada aras rendah. Oleh itu, aktiviti perjalanan juga dilihat pada aras yang sama kerana ia berkait rapat dengan aktiviti mencari tempat untuk sumber makanan. Penyelidikan ini membantu perancang dan pereka taman memahami pemilihan serta komposisi dan konfigurasi pokok yang sesuai dengan keperluan ekologi tupai. Maka, kajian ini mendedahkan faktor asas dalam mereka bentuk taman yang dapat menawarkan aktiviti pemerhatian tupai kepada pengguna taman di Malaysia.

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LIST OF ABBREVIATIONS

GCP	-	Ground Control Points
GIS	-	Geographic Information System
MEA	-	Millenium Ecosystem Assessment
SPSS	-	Statistical Package for Social Sciences

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CHAPTER 1

INTRODUCTION

1.1 Introduction

This chapter presents an overview of wildlife-oriented recreational activity in urban parks. Thus, the purpose of this study is to discover the tree species composition and configuration based on squirrel behaviour pattern in selected urban parks in Malaysian cities which intent to promote the squirrel-observation recreational activity among Malaysian park users. Previous studies (Bjerke and Østdahl, 2016; Larson *et al.*, 2016; Goddard *et al.*, 2013; Keniger *et al.*, 2013) suggested that wildlife viewing connects visitors with animals that provide opportunities to learn about wildlife in natural environments. According to Manfredo (2002), observing wildlife and interacting with them is an essential element of high quality outdoor recreation experience. For example, wildlife-friendly gardening has become a growing concept which dedicated to the challenge of incorporating wildlife habitats into urbanized environments (Goddard *et al.*, 2013). Studies have found that interaction with wildlife in the city is important for human health and wellbeing (Fuller *et al.*, 2007; Luck *et al.*, 2011). Inasmuch, many of these benefits depend on some kind of contact between people and urban wildlife such as hearing, seeing, feeding, photographing, or studying. This concept also has become a tool to enhance both urban biodiversity and connectedness to nature (Shaw *et al.*, 2013) and it is also responded to people's desire for nature experiences by helping people encourage and appreciate urban wildlife. Some programs focus on habitat creation for specific species of wildlife, such as butterfly gardening and bee observation.

This chapter was divided into ten sections. It begins with Section 1.1, which is the introduction of this study. Section 1.2 further discussed the background of the study. Next, Section 1.3 discussed the research problems which is wildlife-oriented recreational activities are less popularly practised in urban parks in Malaysia. Section

1.4 discussed the research gap of the study. Further, in Section 1.5, the research aim and objectives were invented to solve the problem and fill the gap of the study. It is formulated along with the research questions in Section 1.6. The scope and the significance of this study are presented in Section 1.7 and 1.8. Finally, the general structure of the thesis is explained in Section 1.9. Then, Section 1.10 summarises this whole chapter.

1.2 Research Background

Urban park plays a crucial role in ensuring that ecosystem services related to outdoor recreation are successfully delivered to the users. This role has been widely recognized. Thus, among the cultural ecosystem services related to urban parks, recreational ecosystem services have an important role (Bolund and Hunhammar, 1999) for securing mental and physical wellbeing. In terms of recreational and cultural values, urban gardens are also aesthetically functioning in meeting the various social and psychological needs of the people. For example, it can be used for social meetings, recreational activities with children, friends and family, and walking to reduce the pressure, among others. Given the activities in this park also help improve physical and psychological wellbeing that is essential to the quality of life of urban residents, the spaces are very valuable ecosystem services in Stockholm, Sweden (Bolund and Hunhammar 1999). It also provides bundles of cultural ecosystem services which not only to serve the community's activities and recreation but also to maintain the ecological functioning of the environment (Baharuddin *et al.*, 2013). Thus, it is well recognized that urban parks have the ability to strengthen the community by promoting social interactions, improving physical and psychological health and making cities and neighbourhoods more attractive to live and work (Sherer, 2006; Shuib *et al.*, 2015; Ward *et al.*, 2010).

Konijnendijk *et al.* (2013) defined the urban park as “delineated open space areas, mostly dominated by vegetation and water, and generally reserved for public use. They are mostly larger, but can also have the shape of smaller ‘pocket parks’ and are usually locally defined (by authorities) as parks”. Braquinho *et al.* (2015) defined urban park as a “large green area which located within the city, are intended

for public use and include landscape features such as trees, shrubs, extended grassy areas, playgrounds or water bodies”. These definitions clearly stated that parks are designed for people to enjoy serene and peaceful environment spaces as well as to involve in leisure and recreational activities. As stated by Maller *et al.* (2005), to connect with nature in an urban park environment, it can be achieved through various means, including the encounter with plants and animals, the participation in recreational activities, the engagement in environmental conservation work, the viewing of natural scenes, the involvement in nature-based therapy programmes and one’s presence in natural settings. Beside recreational values, urban parks also important for urban ecosystem because they provide habitats for wildlife such as birds, small mammals, amphibians or reptiles (Shine and Koenig, 2001; Morrison *et al.*, 1994;). According to Fuller *et al.* (2007) and Luck *et al.* (2011), dealings with urban wildlife are also vital for human health and well-being.

A lot of empirical evidence has recognized the human-environment relationship is beneficial to the public. For example, by interacting with natural elements such as plants or animals would have a positive impact on physical health (Ulrich, 1984; Maas, 2006; Richardson and Mitchell, 2010), psychological well-being (Kaplan, 2001; Bodin and Hartig, 2003; Fuller *et al.*, 2007), and cognitive ability (Han, 2009). As such, wildlife-oriented recreation encourages people to interact with nature and enjoy resources in the environment, it is also considered as a potential approach to conserving wildlife habitats and providing a positive dimension to human-wildlife relations (Manfredo *et al.*, 2003). Wildlife is reported as an added value to the experience in the park if they are aware of its existence (Dick and Hendee, 1986). The past few decades have shown wildlife experience led to a closer travel emotional experience with nature's enjoyment, environmental learning, and finally being able to provide protection to nature (Ballantyne *et al.*, 2011). According to Valentine and Birtles (2004), some wildlife includes cultural elements. For example, wildlife might be part of the background to nature experience like viewing kangaroos from the window of the tourist bus in Australia.

1.2.1 Urban Parks as Wildlife Habitat

The impact of rapid urban development has radically caused many habitat species to be affected. The loss and fragmentation of natural habitats by human activity are examples of the most significant loss. It has also resulted in the loss of biodiversity, which has now caused concern to the entire population of the world (Grimm *et al.*, 2008). For instance, amphibians are one of the most vulnerable vertebrate in the world that are facing the threat of extinction (Baillie *et al.*, 2004). The most common forms of threats faced by such amphibians are habitat loss, habitat fragmentation and isolation, and habitat decline (Cushman, 2006; Hamer and McDonnell, 2008). Thus, urban parks and green spaces are the only space that offers natural habitats in many areas of the city. These gardens vary according to the size, composition and structure of the plants, and the level of human consumption and management. Despite sharing with humans, some gardens are still able to preserve the existence of various types of native birds, and hence urban green sites may have an important role in the conservation of regional biological diversity (Mörtberg and Wallentinus, 2000; Sorace, 2001). For example, the use of native plants, even in a small number can lead to a significantly higher diversity of birds and butterflies in urbanized areas (Burghardt *et al.*, 2009; Lerman and Warren, 2011; Goddard *et al.*, 2013). Therefore, providing parks as a habitat for wildlife is a significant move for biodiversity conservation in the urban ecosystem (Alvey, 2006; Scheffers and Paszkowski, 2012).

Accordingly, parks have often been known as biodiversity hotspots in urban environments (Clergeau *et al.*, 2001; Stagoll *et al.*, 2012). Nowadays, urban parks and greenery constitute important refuges for wildlife in more and more urbanized global environments (Alvey, 2006). Urban parks can offer resources for increasing or maintaining urban biodiversity, especially for bird species (Chiesura, 2004; Strohbach *et al.*, 2009; Schütz and Schulze, 2015). Birds also have the benefits of providing a positive impact on the urban residents by appreciating the city's landscape as well as enhancing the recreation experience in urban gardens (Hedblom *et al.*, 2014). As such, birds are arguably key components of the urban fauna.

Urban parks that make up a variety of habitats including plant species can sustain a higher biodiversity (Fernández-Juricic, 2004). For example, community gardens are often planted with various types of vegetables, herbs, plants and flowering plants, although many species are not native. In cities where community gardens are the commonplace for urban dwellers, they contribute substantially to green space and biodiversity as a whole by providing a place for migratory birds and to landscape heterogeneity (Krasny and Tidball, 2009). Community gardens are also an opportunity for residents in certain areas of the city to experience biological diversity and therefore, they can improve psychological and physical health (Louv, 2006).

1.2.2 Viewing Wildlife in Urban Parks

Many studies have shown the importance of non-material benefits provided by the ecosystem and especially by cultural landscapes, which are shaped by interactions of intimate human nature. For example, garden visitors seek and engage in an informal and uncontrollable opportunity to view or photograph wildlife to enhance their excitement (Bath and Enck, 2003). Thus, research studies in Conservation Biology, Landscape and Urban Planning, Leisure Science, Restoration Ecology, and Outdoor Recreation and Tourism have focused on the importance of nature in maintaining human health and the enjoyment derived from observing and interacting with wildlife (Fuller *et al.*, 2007; Luck *et al.*, 2011; Dallimer *et al.*, 2012; Parker and Nilon, 2012; Folmer *et al.*, 2016). The non-consumptive use of wildlife is mostly based on the aesthetic value of wildlife (Chardonnet *et al.*, 2002). Visitors are more likely to find hidden natural areas solely to watch wildlife and experience the wildlife-human interaction. For example, people spend time in zoos, parks or nature reserves for animal or wildlife observation as part of their interaction with nature and its elements. As such, wildlife in urban parks can play a major role as some of the visitors as they have the potential to increase the attractiveness of the park experience. Wildlife including birds, fish, reptiles, butterflies, and small mammals such as chipmunk and squirrels are usually found in the urban park (Lyons, 1982; Dick and Hendee, 1986; Randler *et al.*, 2007; Leite *et al.*, 2011).

Wildlife viewing connects visitors with animals that provide opportunities to learn about wildlife in natural environments. Linked to this, wildlife-friendly gardening has become a growing concept which dedicated to the challenge of incorporating wildlife habitats into urbanized environments (Goddard *et al.*, 2013). This concept is a tool to enhance both urban biodiversity and connectedness to nature (Shaw *et al.*, 2013) and it is also responded to people's desire for nature experiences by helping people encourage and appreciate urban wildlife. Some programs focus on habitat creation for specific species of wildlife, such as butterfly gardening and bee observation.

Observing wildlife and interacting with them is an essential element of high quality outdoor recreation experience (Manfredo, 2002). Studies have found that interaction with wildlife in the city is important for human health and wellbeing (Fuller *et al.*, 2007; Luck *et al.*, 2011). Many of these benefits depend on some kind of contact between people and urban wildlife such as hearing, seeing, feeding, photographing, or studying. As suggested by Valentine and Birtles (2004), humans often have extremely intense and deeply personal experiences through wildlife watching and this may lead to outcomes that are extraordinary in their impacts on people's lives. In *The Malay Archipelago* book authored by Russell Wallace (1962, Chapter xxiv, pg.257-258), he described the depth of emotion and excitement generated by his first encounter with birdwing butterfly in the wild:

“I found it to be as I had expected a perfectly new and most magnificent species, and one of the most gorgeously-coloured butterflies in the world. ... more than 7 inches across the wings, which are velvety black and fiery orange The beauty and brilliancy of this insect are indescribable.... On taking it out of my net and opening the glorious wings, my heart began to beat violently, the blood rushed to my head, and I felt much more like fainting than I have done when in the apprehension of immediate death. I had a headache the rest of the day so great was the excitement produced by what will appear to most people a very inadequate cause”.

Therefore, Manfredo and Larson (1993) have outlined the wildlife viewing experiences includes bringing back pleasant memories, experience excitement, being creative through engagement in activity such as sketch, paint or take photographs.

1.3 Problem Statement

Scholarly studies have shown that interacting with outdoor habitats, parks and nature forms promote human health such as people will become more effective in stress management (Kuo, 2001), accelerated recovery from illness (Cimprich and Ronis, 2003) as well as improved cognitive functioning (Wells, 2000; Taylor *et al.*, 2001). In terms of human-wildlife interactions in the parks, the visitors seek out and engage in informal or uncontrolled opportunities to view or photograph wildlife to enhance their enjoyment (Bath and Enck, 2003). Nevertheless, a key factor in watching wildlife is being able to experience animals in the wild, to observe their natural behaviour and to appreciate their beauty (Tapper and Waedt, 2006). However, most park users in Malaysia were not aware of wildlife watching activity in the urban park and do not participate in substantive interaction with the wildlife. For instance, research was done by Sreetheran, (2017) on park use, preference and behaviours among the residents of Kuala Lumpur found that people visited an urban park mostly to get fresh air (74.7%) whether by walking or strolling alone, with friends or family. Similarly, Siti Rasidah *et al.* (2015) found that social activities such as flying kites, boating, picnic, meeting friends, eating, capture photo, and playing at the playground are the determinant factors of people visiting parks in six public parks in Klang Valley. As also listed by Razak *et al.* (2016), in Penang Botanic Garden and Labuan Botanic Garden, the main activities are jogging, walking, tai-chi, picnicking, playing playground equipment, and family gathering. However, Maulan (2015) found watching birds as the only wildlife which observed by the users in Taman Tasik Seremban, N.Sembilan. Table 1.1 shows the studies on recreational activities commonly performed in urban parks in Malaysia.

Table 1.1 List of literature study of common activities performed in urban parks in Malaysian cities

Author	Year	Urban Park	Activity
Nath <i>et al.</i>	2018	Three selected urban parks in Kuala Lumpur, Malaysia	<ul style="list-style-type: none"> • Jogging • Outdoor gym • Social gathering • Viewing nature
Sreetheran	2017	Five urban parks in Kuala Lumpur, Malaysia	<ul style="list-style-type: none"> • To get fresh air • Reduce stress and relax • Exercise and play games • Gathering with family and friends • Enjoy nature • Meet people
Siti Rasidah <i>et al.</i>	2015	Six public parks in Shah Alam and Kuala Lumpur, Malaysia	<ul style="list-style-type: none"> • Fly a kite • Boating • Picnic • Meeting friend • Scenic view • Playing at playground
Maulan	2015	Taman Tasik Seremban, N.Sembilan	<ul style="list-style-type: none"> • Observe nature • Watching birds • Playing • Walking • Jogging • Picnic • Family gathering

This shows clearly that wildlife-oriented recreational activity among park visitors in Malaysia is still at a low level. In order to obtain enjoyment and interesting experiences of recreational activities in urban parks, one of it is that the human-wildlife interaction activities such as hearing, seeing, feeding, photographing, and studying must exist. This wildlife-observation recreational activity may also help increase the environmental sensitivity of park visitors, enhance their awareness and enjoyment of wildlife and thus brings a beneficial impact on human health and wellbeing.

1.4 Research Gap

Whilst there are ample studies on vegetation structure for wildlife habitat in wetland (Richter and Azous, 1995), urban areas (Fernández and Simonetti, 2013; Idilfitri and Mohamad, 2012; Khera *et al.*, 2009; Mohamad *et al.*, 2013; Sulaiman *et al.*, 2013), and suburban forest (Lesiński and Gryz, 2012), few studies focused on the tree characteristics in urban park which has a potential for squirrel's habitat. According to Morrison *et al.* (1998), vegetation structure is an important determinant of habitat occupancy of many wildlife species. In zoology, understanding of trees is often the most valuable information in order to know the number and species of animals that can be supported in certain areas (Shaw *et al.*, 1998). In urban planning and urban greening, by providing protection as well as indigenous plant communities will be a powerful tool for developers, planners and homeowners in urban environments in ensuring effective wildlife management (Johnson, 1995). This knowledge is essential to formulating tree species composition and configuration for an urban park to provide opportunities for wildlife-oriented recreational activity to occur.

Furthermore, most studies in urban areas pay more attention to species of birds or iconic species and few has focused on mammals, reptiles, amphibians, invertebrates and aquatic species (Garden *et al.*, 2006). Hence, this study asks the question of how watching squirrels can be done in urban parks? What are the characteristics of the trees that permit watching squirrel possible? According to Thorington and Ferrel (2006), it is estimated that there are 278 species, or unique types of squirrels of the world and the highest ecological diversity of squirrels are in Southeast Asia which consists of 55 species of tree squirrels, 15 species of ground squirrels and 36 species of flying squirrels. According to Emmons (1980), out of the 22 of the squirrels living genera, 20 are mostly or completely tropical. There are the beautiful squirrels, the giant squirrels, four species of pygmy squirrels, a large number of flying squirrels and several more specialized squirrels. Thus, this region is frequently referred to as “squirrel headquarters of the world” (Figure 1.1). The tree and flying squirrels are considered as important engineers in ecosystems because of

the significant role they play in the regeneration of forests around the world (Thorington and Ferrell, 2006; Koprowski and Nandini, 2008).

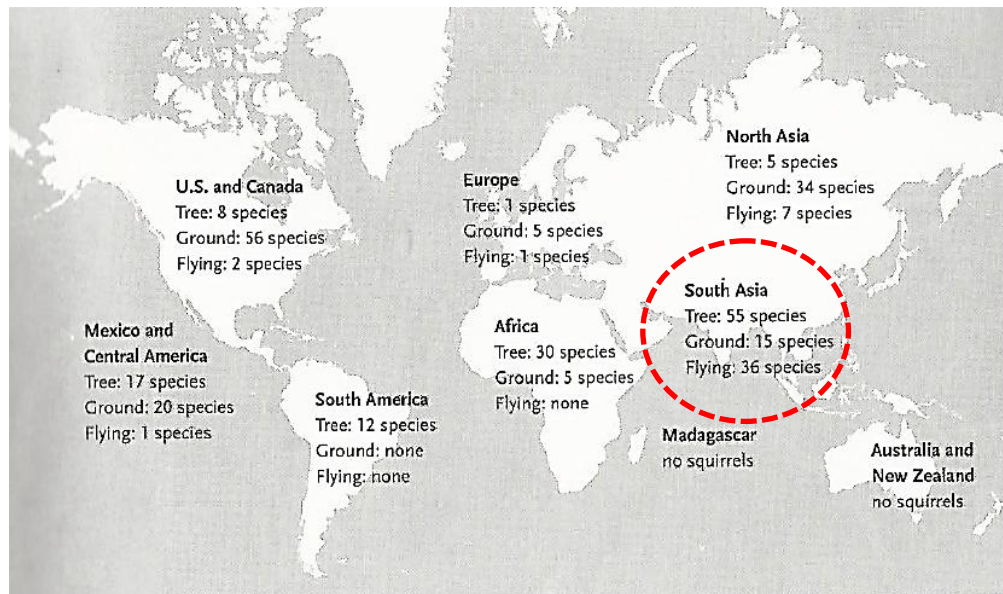


Figure 1.1 A world map showing the highest distribution of squirrels in South Asia region (Thorington and Ferrel, 2006)

Thus, this study focused on a characteristic of trees that has received relatively little attention to date in providing habitat for squirrels in Malaysian urban parks. It focuses on three main attributes of the trees which are the species composition, configuration and the tree storey which is the vertical space used by the squirrels in urban parks. These will promote squirrel-observation recreational activities such as photographing squirrel foraging or feeding behaviour. Therefore, urban parks should provide the opportunity to foster awareness and knowledge of visitors about wildlife and thus, stimulating squirrel-observation recreational activity and will also enhance the pleasure of visiting the parks.

1.5 Research Aim and Objectives

This study aims to discover the tree species composition and configuration used by the squirrels which suitable for squirrel-observation recreational activity in the urban park in Malaysian city. It also includes the tree storey which refers to the vertical space used by the squirrels. Squirrel-observation recreational activity is part

of cultural ecosystem services provided by the green spaces in the urban ecosystem. Hence, to achieve the goal, four objectives are formulated as follows:

- i. To identify the squirrel's behaviour pattern in urban parks;
- ii. To investigate tree species composition and configuration that influence squirrel's behaviour pattern in urban parks;
- iii. To investigate the vertical space mostly used by the squirrels in urban parks and;
- iv. To develop a schematic design model of tree species composition and configuration for squirrel-observation recreational activity in urban parks.

1.6 Research Questions

This study pursuing the four research questions based on the background of the study, aim and objectives as follows:

- i. What is the pattern of daily activity rhythm and budget of the squirrels in urban parks?
- ii. What is the type of tree species composition and configuration that frequently used by the squirrels when performing their daily activities in urban parks?
- iii. How does the lower, middle and upper level of trees influence the squirrel's daily activity pattern in urban parks?
- iv. How does the schematic design model of tree species composition, configuration and storey can be developed in order to support squirrel-observation recreational activity in urban parks?

1.7 Scope of Study

The focus of this study is to discover the tree species composition and configuration which influence the squirrel's behaviour pattern which living in three selected urban parks in Malaysian cities. The parks are Taiping Lake Gardens, Perak, Hutan Bandar, Johor Bahru and Botanical Garden, Putrajaya. This study also

includes the tree storey level which refers the vertical spaces used by the squirrels. Based on the literature studies, the daily squirrel's behavioural activity pattern which involved in this study are the rhythm and budget of plantain squirrel (*Callosciurus notatus*) in relation to the time of day and the trees they used. Hence, the nine observable daily squirrel's behaviours which can be found in urban parks are foraging, feeding, traveling, chasing, resting, grooming, observing, vocalization and drey building. Considering plantain squirrel is an arboreal species and mainly dependence on the trees for food, shelter and movement, it is apparent that the tree species composition and configuration of the urban parks are the important variables of their habitat use. The frequency of squirrels sighting in particular trees in the parks is measured from sunrise to sunset. Inasmuch, this will give an insight understanding of the relationship between the trees and the squirrels in performing their daily activities in the urban parks. Consequently, this will permit the squirrel-observation recreational activity among Malaysian park users. Eventually, this study emphasizes how squirrel-observation recreational activity can be developed as an important part of recreational activities which can be conducted in urban parks in Malaysian cities.

1.8 Significance of Study

The presence of wildlife in urban ecosystems can have a positive impact on the quality of life of the population and the educational experience of urban people and ultimately contribute to the preservation of biodiversity in the less disturbed ecosystems (Savard *et al.*, 2000). In Europe's urban park study, for example, it is the most prominent recreational ecosystem service (Bertram and Rehdanz, 2015), including experiencing nature or watching specific animals or plants (Fischer *et al.*, 2018). The significance of the presence of wildlife in urban parks contributes to aesthetic, emotional, psychological and social experience for city dwellers whereby, for some people, it is a greeting, the joy of sharing space with wild creatures, and observing wildlife can be a calm and peaceful experience for viewers. Therefore, this study is considered important, as the studies on discovering suitable tree species composition and configuration for squirrel's habitat in urban parks in Malaysian cities are scarce. The schematic design model which will be recommended by this study will help park managers and designers to understand the tree species

composition and configuration as well as the tree storey (vertical space) use by the squirrels in urban parks in creating suitable habitat for promoting squirrel-observation recreational activities among park visitors in Malaysian urban parks.

1.9 Structure of the Thesis

This thesis comprises of five chapters as follows:

1.9.1 Chapter 1 – Introduction

This chapter presents the research background. It also includes the research aim and objectives in response to identifying the research problem and gap, that is, the need to understand both the squirrel behavioural activities and tree characteristics that influence their behaviour for promoting squirrel-observation recreational activity in urban parks. The scope and significance of the study and the overall thesis structure are also presented in this chapter.

1.9.2 Chapter 2 – Literature Review

This chapter reviews the concept of human-wildlife interaction in urban parks. It defines the benefits of human-nature relationship linking to human health and wellbeing. It also reviews the factors that influence wildlife behaviours in the urban ecosystem. The chapter also comprehensively discusses the roles of urban green spaces, particularly urban parks as a biodiversity hotspot and a source of urban wildlife habitats. Then, it also discusses the human-wildlife interaction in urban ecosystems. Finally, the chapter reviews the squirrels around the globe as well as in urban parks (context of this study) for which to understand their habitat use and behavioural activity.

1.9.3 Chapter 3 – Research Methodology

This chapter presents the research methodological approach carried out in the study. It explains steps taken to achieve four research objectives and to answer four research questions that have been set for this study. Direct observation and focal animal sampling and GIS were used to record and map the squirrel daily activity pattern in the urban park according to the circadian rhythm of this species that has been identified through literature review. The observation sampling plot is based on the radius that has been identified according to the appropriate radius which based on high visibility of squirrels during the preliminary study that has been conducted in each study area. Data for tree location, composition and configuration, and tree height (to define a vertical range) are obtained from the direct observation on site. This is followed by the types of analysis used in this study. The analysis includes the Chi-square independence test with the aid of GIS composite map in order to put in relation all the variables.

1.9.4 Chapter 4 – Results and Discussions

This chapter discusses the results and findings of the study. The findings are divided into two sections; i) the squirrel daily activity pattern in terms of activity rhythm and budget, ii) tree species, composition and configuration and iii) tree storey in terms of vertical space use by the squirrels. The findings on the squirrel's behavioural activity pattern indicate their daily activities on different tree characteristics. Next, the findings on tree species, composition, configuration and storey (vertical space use) indicate the factors that influence squirrels behavioural patterns in manmade ecosystems particularly urban parks. Finally, the chapter discusses how the selection of tree species, its composition and configuration as well as vertical space used by the squirrels in urban parks can be determined through the understanding of their behavioural activity pattern that related to their natural and habitual behaviour.

1.9.5 Chapter 5 – Conclusion and Recommendation

This chapter concludes the thesis with a discussion of the overall findings including the practical design implications of the body of work. It discusses the factors that should be taken in selecting and organizing trees in urban parks for promoting squirrel-observation recreational activities as one of important recreational activities in urban parks. Finally, the study recommends the schematic design model of an ideal selection of tree species and its composition and configuration as well as vertical spaces use for certain squirrel activities that to be observed in the parks.

1.10 Summary

In sum, this chapter explained urban wildlife provides a variety of benefits to humans, including opportunities for physical and health, recreation, scientific, ecological and historical use (Conover, 2001). Therefore, urban parks for urban residents are crucial as it contributes to the quality of their life. The important part of the benefits is frequent and close relationships with nature including contacts with wildlife within the park. Hence, it is great to see the design of the new park and the management of existing urban parks can maximize the benefits of interacting with wildlife that inhabits the parks. The diversity of trees and wildlife species offers high value to the park to be seen as providing its recreational services to the surrounding people. The flow of the research has shown in Figure 1.2 to guide the contents of overall chapters in this study.

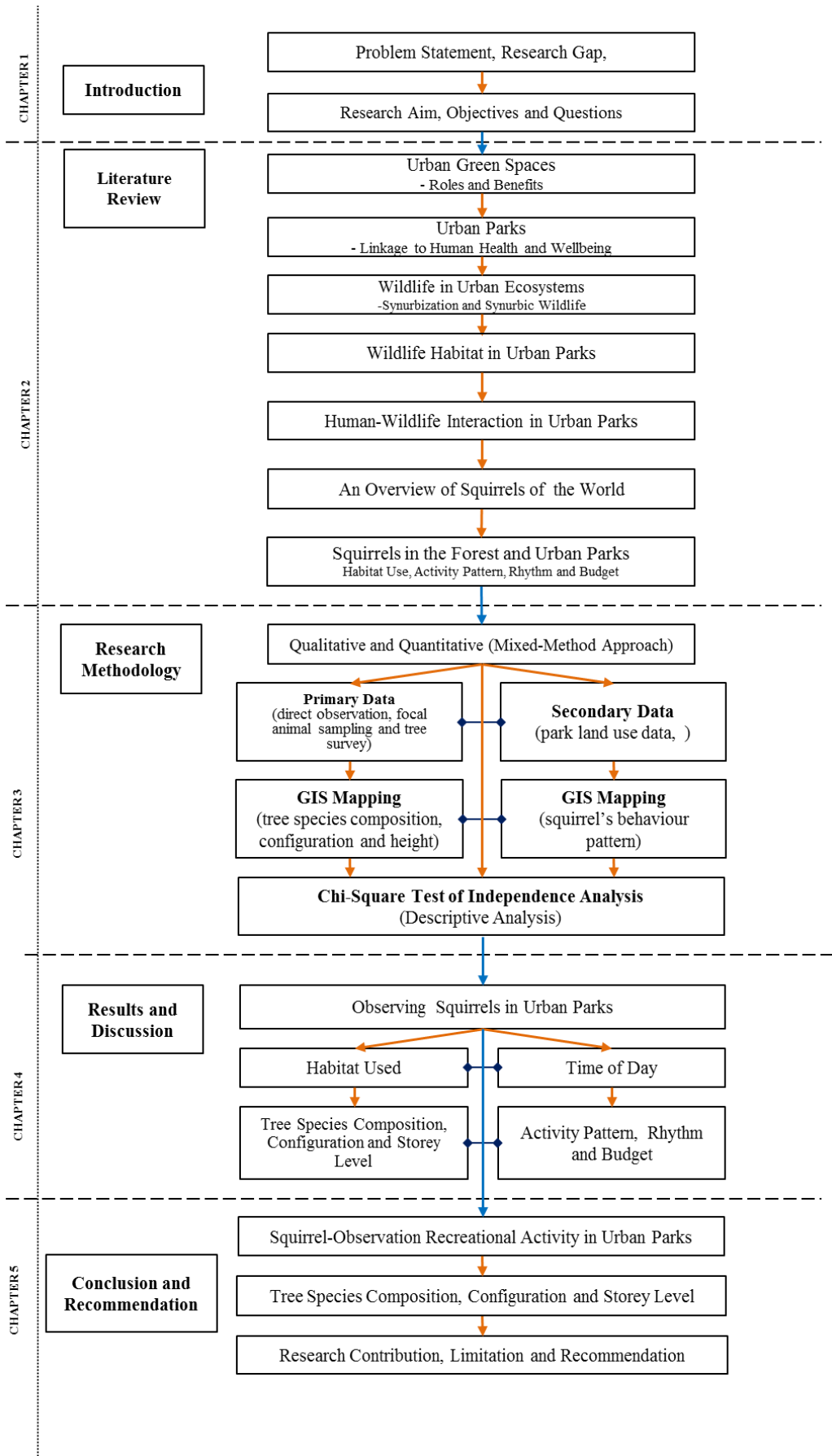


Figure 1.2 Research flow of this study

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