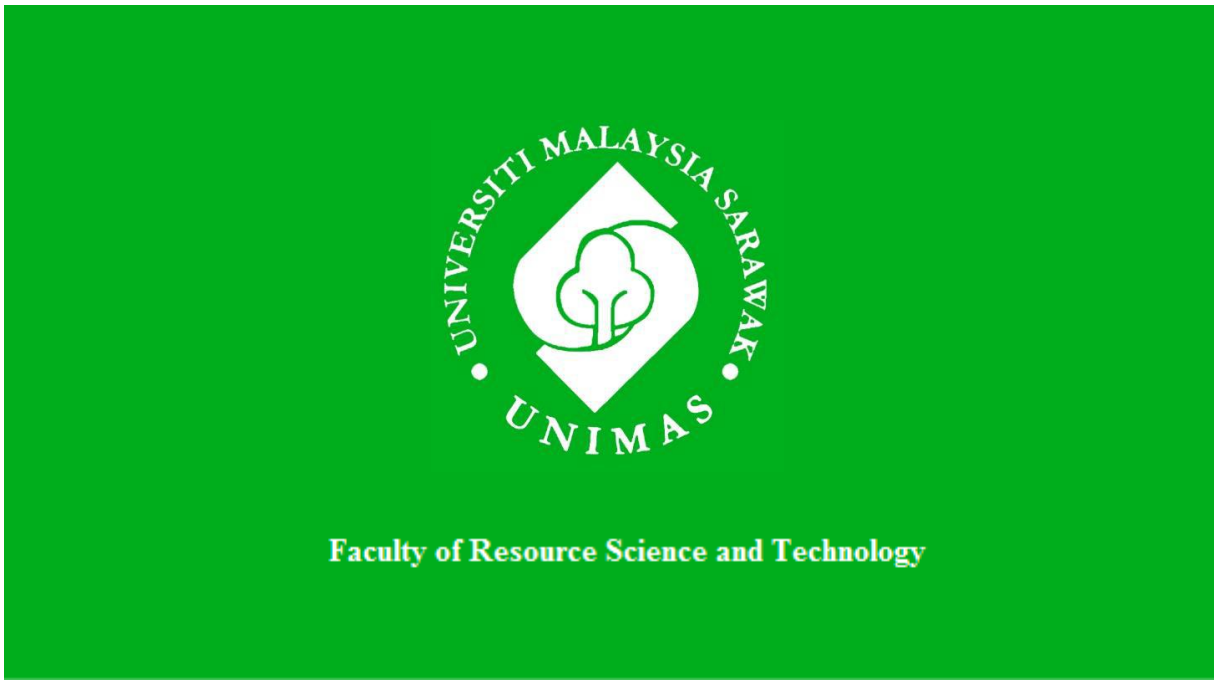

SPECIES SELECTION AND PLANTING DISTANCE OF URBAN TREES AROUND KUCHING CITY, SARAWAK

TUAN MUHAMMAD SYAFIQ BIN TUAN HASSAN

Bachelor of Science with Honours
(Plant Resource Science and Management)
2015

UNIVERSITI MALAYSIA SARAWAK

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LIST OF ABBREVIATIONS

CO_2	Carbon dioxide
DBH	Diameter breast height
GHG	Green house gases
JKR	Jabatan Kerja Raya
m	Meter
n.d.	No date
PM	Particle matter
SDI	Simpson's Index of Diversity
US	United States of America
VOC	Volatile organic compound
^{O}C	Degrees Celsius
%	Percent

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ABSTRACT

Urban forest is important because it assists in creating a good environment for human being to live in. Due to the roads expansion and the increasing area for parking lots, certain species may not be able to survive in that particular area because of the lack of space and land. Failure to identify the most suitable tree species for planting in the area may cause various negative impact directly or indirectly. A survey was carried out to assess the species selection and planting distance of urban trees at Tun Abang Haji Openg road, Tunku Abdul Rahman Yaakub road, Tun Ahmad Zaidi Adruce road, Bako road, Kolej road and Rock road. There are trees that was planted with ample planting spaces, however the same pattern at old planting sites were repeated again at new planting sites. The implications of species selection and the importance of recommended planting distance are discussed.

Keywords: Species selection, planting distance, urban forestry.

ABSTRAK

Hutan bandar adalah penting dalam mewujudkan persekitaran yang baik untuk didiami oleh manusia. Pelebaran jalan dan peningkatan kawasan yang digunakan sebagai ruang tempat letak kereta menyebabkan sesetengah spesies pokok gagal untuk bertahan lama di kawasan tertentu disebabkan kekurangan ruang dan tanah. Kegagalan dalam mengenalpasti spesies yang paling sesuai untuk ditanam di kawasan tertentu mungkin boleh menyebabkan banyak impak buruk secara langsung atau secara tidak langsung. Satu kajian telah dijalankan untuk menilai berkenaan pemilihan species dan jarak penanaman pokok bandar di Jalan Tun Abang Haji Openg, Jalan Tunku Abdul Rahman Yaakub, Jalan Tun Ahmad Zaidi Adruce, Jalan Bako, Jalan Kolej dan Jalan Rock. Terdapat pokok-pokok yang ditanam dengan ruang penanaman yang luas namun terdapat juga kesilapan sama dari segi jarak penanaman di tapak penanaman lama yang berulang lagi di tapak penanaman baru. Kesan-kesan pemilihan spesies pokok dan kepentingan jarak tanaman yang disyorkan telah dibincangkan.

Keywords: Pemilihan spesies, jarak penanaman, perhutanan bandar.

CHAPTER 1

Introduction

A study by Bucur (2006), found that trees improve several architectural and engineering functions, thus providing a green infrastructure for communities in the city. Any landscape design will include the tree in its foundation plan. Whether the planting is suitable or not depend on the type used and their location. If trees are given appropriate care, there will not be any surprise that it will be live for more than 100 years. Due to the permanency of urban trees and their importance to the environment, trees planted must be suitable and relevant species.

Urban forest is important because it assists in creating conducive environment for human being to live in. The major purpose of planting urban tree is to minimize the negative impact of deforestation and provides the benefit of forest to human (Alberti, 2005). One of the important elements of urban forest is urban ecological systems. Urban ecological systems can be defined as the intricate interactions among social, economic, institutional, and environmental variables (Alberti, 2005).

Trees cool the particular area in the environment by providing shade. This is vital especially for the parking lots area. According to Beatty (1989), parking lots occupy about 10 percent of the land in cities and 20 to 30 percent of the downtown core area. Parking lots area can be the most significant contributors of heat, air pollutants, water pollutants, and visual blight in the city area. Parking lots area without trees can be considered as a small version of the heat islands, where temperatures can be significantly higher than surrounding areas. However, it is different if there are trees planted, as the tree canopies will reduce the air temperature.

Although the bulk of hydrocarbon emissions come from tailpipe exhaust of vehicles, whereby 16% of hydrocarbon emissions are from evaporative emissions that occur when the fuel delivery systems of parked vehicles are heated (McPherson *et. al*, 2002). Both types of emissions are sensitive to local microclimate. The evaporative emissions will be greatly reduced if cars are shaded in parking lots. As trees reduce temperatures and smog and with a healthy urban forest, air quality can be drastically improved (Nowak, 2000). Besides, tree contribute to reduce the heat island affect in urban areas, hence trees also help in lowering air temperatures. The reduction of temperature will not only lowers the energy use, but also enhances air quality, as the formation of ozone is closely related to atmospheric temperature.

The urban forest is the land in and around areas of intensive human influence, ranging from small communities to dense urban centers, that is occupied or potentially occupied by trees and associated natural resources (Kuser, 2000). The definition of urban forestry is the art, science, and technology of managing trees and natural systems in and around urban areas for the sake of communities (Brandom, 2013).

In term of environmental functions, urban trees can enhance air quality by mitigating air pollution and greenhouse gases (Brandom, 2013). Generally, trees convert carbon dioxide (CO_2) into nutrients via photosynthesis process. Without photosynthesis by trees, CO_2 which is one of the common greenhouse gas would lead to smog and unhealthy environment. Shading streets, parking lots, and rooftops provide as much soil area as possible for planting areas to promote vigorous tree growth (McPherson, 2001). Trees cool buildings during hot weather and reduce snow accumulations during winter by providing shade and a barrier to wind. From economical aspect, this is good enough as it can lower the costs spend on heating and cooling the building.

Besides providing benefit in environmental and economic aspects, urban forests also indirectly contribute in terms of social aspect. People tend to gather where the green spaces are available in city. Trees help to reduce noise pollution by absorbing amounts of urban noise and this can reduce stress for those who living in the hectic city. One the other hand, there were fatal cases happened to the people that involved the failure of urban trees management. Thus, there is a need to observe and assess the tree species at the North Kuching (DBKU) area as it will provide a vital database for maintenance purposes and future sustainable land use planning. Due to the road expansion and the increasing area for parking lots, certain species may not be able to survive in that particular area because of the lack of space and land. Failure to identify the most suitable tree species for planting in the area may cause various negative impact directly or indirectly. Therefore, it is important to survey the diameter breast height (DBH), planting distance, structure, hazard, and condition of these trees for sustainable land use management.

The objective of the study is to identify and assess the trees that have been planted in old planting site and new planting site in Kuching City. The data obtained at both site were studied to obtain the importance information that will lead to suitable maintenance work.

CHAPTER 2

Literature Review

2.0 Introduction

Urban forests provide communities with environmental, economic and social benefits and habitat for fish and wildlife. The basis of an urban tree's value could be emotional, aesthetic, or it could be restrictively utilitarian. The 'value' of something is often hard to classify due to the significant reason. But in the case of the urban tree's value, most communities considered the cost that the public willing to spend on tree care and management as a good indicator of tree's value.

Urban forest is an ecosystem of the vegetation, especially trees in and around communities that may consist of street and yard trees, vegetation within parks and along public rights of way and water systems (American Forests, 2014). Birds and small animals made trees as their habitat. The trees chosen as shelter for animals because of the damaging of their natural environment especially in the urban areas. Thus, urban forests are not only about the trees in the city, but rather, they are a critical part of the green infrastructure that makes up the city ecosystem.

Trees intercepting airborne particles, reducing heat and absorb pollutants help in cleanse the air. Air pollutions can be reduce by trees by lowering air temperature through respiration (Nix, 2013). This is really important and beneficial to the people and community.

According to McGinley (2008), species diversity is a measure of the diversity within an ecological community that involves both the richness of the species (the number of species in a community) and the evenness of species' abundances. It is one vital component of the biodiversity concept. An ecosystem is said to be more diverse, according to the more technical definition, if

species present have equal population sizes and less diverse if many species are rare and some are very common.

Too many trees planted every year will not guarantee the large shade from trees that can contribute greatly towards the city as the trees will not survive long enough to reach its effective size. Many factors can influence the tree growth but the main factors in urban areas are the planting methods and longevity relationship (Arnold, Hendry, 1993). Trees are not planted in a proper way can lead to waste of resource and manpower. It can be concluded here that sustainable trees are vital element for a sustainable city.

2.1 Species Selection

According to Miller (1997) the process for selecting species for urban uses may be facilitated through the use of a Species Selection Model (Figure 1). Site factors consist of cultural and environmental constraints, where cultural constraints refer to physical limitations of the site caused by human structures and activity, and environmental constraints refer to insects, diseases, climate and microclimate, and soils.

Social factors include neighborhood and community values, functional utility, species aesthetics, public safety, and negative social externalities. Economic factors include establishment, management, and removal costs (Miller, 1997). However, in such a model, the soils are probably only a limited constraint, since they are usually accepted as they are. In the future, it would be desirable to optimize the growing conditions by investing in site preparation beforehand, rather than by rectifying problems later.

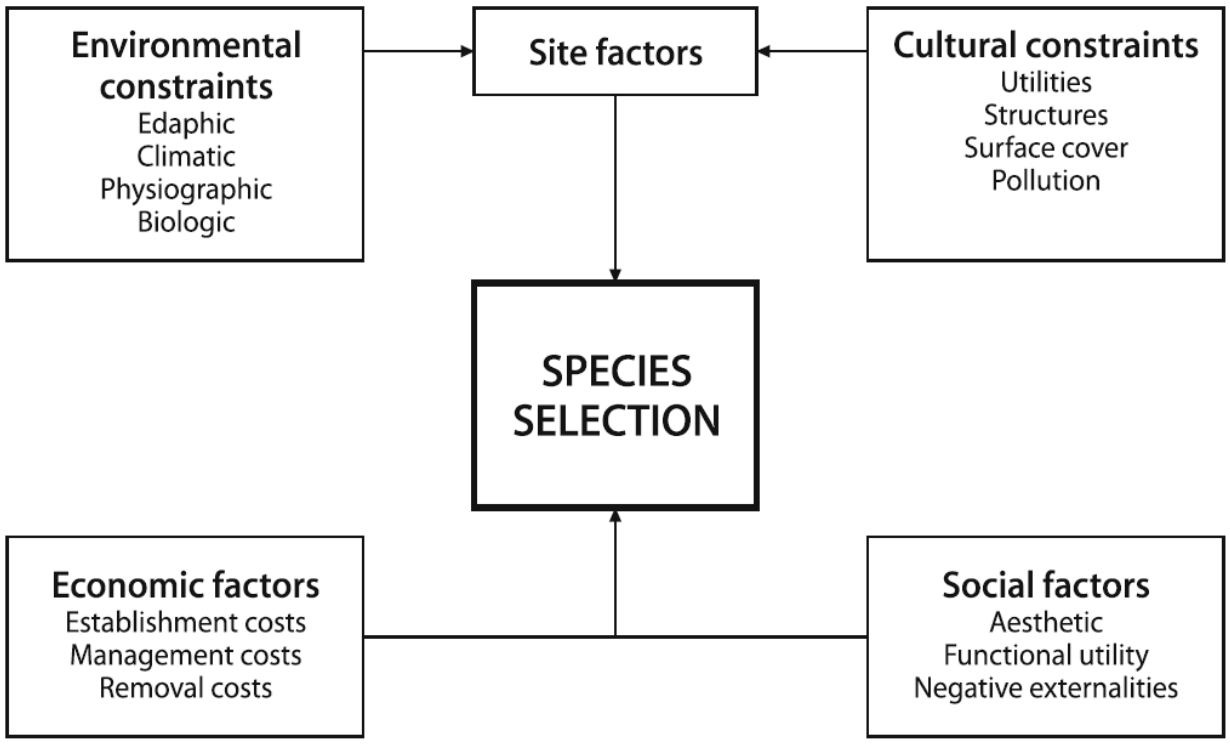

Figure 1. Factors important in a model for selection of species for urban areas (Miller 1997)

Preferences vary according to region. For example, in northern Europe trees like *Betula* spp. are highly appreciated because of their light shading. By contrast, in southern Europe, denser shade is preferred. The composition of species in urban situations also relies on the ecological and epidemiological knowledge of designers and planners. The mixture of *Sorbus aucuparia* and *Juniperus communis* for example, may yield serious problems with rust (*Gymnosporangium cornutum*) because the fungus alternates between the two species (Wennström and Eriksson 1997).

According to Wennström and Eriksson (1997), some species may have invasive characters, and thus are not desirable in all situations. Examples of such plants are found in *Acacia*, *Acer*, *Ailanthus*, *Ilex*, *Prunus*, *Laburnum*, *Sambucus* and *Rhododendron*. Special selection criteria are needed in particular environments, such as for example seashores.

Tree selection might be the most challenging steps in urban greening. Selecting plants that will survive well to their new environment and will fulfill their intended function is extremely important to success of a planting and the ease with which it can be maintained. Another important factor is the quality of young plant. An ideal tree that require less maintenance come from a good young plant.

Trees have been widely used in urban areas with different species having different characteristics, which make them suitable or unsuitable for planting in different area. If it is not suitable, it will retarded the growth of the tree and often become harmful to surrounding people and property. One of the significance of the species selection is to overcome or at least minimize these problems.

2.2 Kyoto Protocol

The Kyoto Protocol is a treaty that was negotiated at the city of Kyoto, Japan on December 11th 1997 and came into force on February 16th, 2005. This protocol is really significant as it introduces for the first time, legally binding greenhouse gas (GHG) emission commitments for the developed countries. The commitments agreed to lead to an overall global reduction of minimum 5% of GHG level by 2008-2012. The major GHG is CO_2 and its biggest source is fossil fuels burning for energy. Trees play a great role in succeeding the goal of the Kyoto Protocol especially in minimizing the impact of global warming and other effects cause by GHG.

2.3 Urban Heat Island

Temperature in most urban areas are warmer than suburban rural areas. This phenomenon commonly known as the "urban heat island" effect (Maurice *et.* al, 1999). Fewer trees, and other natural vegetation to shade buildings, block solar radiation and cool the air by evapotranspiration in urban areas lead to urban heat island. According to Chang (2000), in Los Angeles, for every degree Fahrenheit the temperature rises above 70 ^{o}F, the incidence of smog increases by 3%. This study suggested that the urban heat islands are not only hot, they also smoggier. At high temperature, the pollutants undergo some photochemical reactions and it will create smog as a final products.

2.4 Functions of urban trees

2.4.1 Carbon sequestration

There are two ways for the urban trees reduce the amount of carbon in the atmosphere. The first one is simple. They store carbon as they grow. Second, trees indirectly reduce the amount of carbon dioxide released into atmosphere thus reducing the energy needed for urban heating and cooling. The less the energy needed for urban heating and cooling, the less amount of carbon dioxide need to be produced by power plants. In the Chicago study, trees annually sequestered the equivalent amount of carbon emitted from all form of transportation in one week (Nowak *et al.*, 1994). The most important things to bear in mind when we discuss about carbon sequestration is the rate of C sequestration can be greatly affected by management and ecological factors (Kimble et al., 2003).

2.4.2 Trees are carbon sinks

CO_2 is a main cause for global warming. However, a tree absorbs and locks away CO_2 in the wood, roots and leaves in order to produce its food. A forest really contribute towards better environment as they act as a carbon storage area or a ‘sink’ that can lock as much carbon as it produces. This processes stores carbon as wood and avoid the carbon to exist in a form of ‘greenhouse’ gas (Blackburn, 2012).

2.4.3 Trees shade and cool

Local urban heat island effects is reduced by trees through shading, evapotranspiration, and reducing cooling demands. Studies have shown that parts of cities without cooling shade from trees can be ‘heat island’ with temperature as much as 12 degrees Fahrenheit higher compared to surrounding areas (Blackburn, 2012). This is happening because trees and other vegetation enhances air quality by lowering the level of particulate air pollutants and gases such as ozone.

In highly settle urban areas, solar energy is reflected and absorbed by the building surfaces. But in the cities that have urban forest, the solar energy is greatly used by the trees for its transportation and photosynthesis processes. It cause a significant reduction in temperature of cities that have urban trees.

2.4.4 Trees control noise pollution

Proper design of trees and shrubs planting can reduce the noise in a hectic city. Leaves and stems of the urban trees can reduce the noise by scattering it, while ground absorbs sound (Aylor, 1972). Trucks, trains, and planes in cities can potentially produce noise that exceeds its healthy levels. More important to human, plants absorb more high-frequency noise than low frequency. It is really beneficial to humans as usually higher frequencies are most distressing to people (Cook, 1978). Besides, trees also can reduce the unhealthy levels of noise by making its own noise. The noise that is produced by trees here refer to the noise as wind moves tree leaves or as birds sing in the tree canopy. These harmonious sounds may make individuals less focus of unhealthy noise that can make them stress (Robinette, 1972).

2.4.5 Trees absorb air pollution

Air pollution may be defined as the presence in the outdoor and/or indoor atmosphere of one or more contaminants or combinations thereof in such quantities and of such duration as may be or may tend to be harmful to human, plant, or animal life, or property or the conduct of business (Wark et al., 1998). Urban forests divert particulates and the soil below assimilates these pollutants. Via several processes, trees set off sedimentation of particulates onto the leaf and the surface of the branch. After particulates were washed into the soil, some of them may decompose and some may remain in the soils (Miller, 1997).

Recently, scientists have emphasized that tree's function in the storage of CO_2, a gas that has been increasing in concentration in the atmosphere to assist reduce greenhouse effect. Trees effectively remove CO_2 from the atmosphere by consuming it during their growth processes

(Nowak, 1994). Furthermore, urban trees also absorb gaseous pollutants such as O_3, nitrogen dioxide (NO_2), and sulphur dioxide (SO_2) through leaf surfaces. Other than releasing oxygen through photosynthesis, trees also intercept PM10 (Particulate Matter up to 10 micrometers in size) such as ash, pollen and smoke.

2.4.6 Emission of Volatile Organic Compounds (VOC)

Curtain trees out send VOCs into the atmosphere. VOC are natural compounds that create essential oils, resins, and other plant products. VOC is very useful and some of its function are attracting pollinators and repelling predators. VOC can contribute to the O_3 and CO formation. Trees generally lower the air temperature and this factors can influence the emission of VOC because the emission of VOC depends on temperature. It is believed by researchers that increase number of trees planted will lowers the VOC emission and indirectly reduce the O_3 and CO level in urban areas.

2.4.7 Energy conservation

Trees can help to conserve energy and directly or indirectly help to reduce the cost of cooling and heating of buildings. Tree directly assists reducing the heat gain through walls, windows and roofs by shading the building entirely or partially. While the indirect effects of tree are lowering the outside air infiltration rate by reducing surrounding wind speeds, reducing the heat gain into the buildings by lowering surrounding temperatures via evapotranspiration in summer and sometimes increasing the latent air-conditioning load by adding moisture to the air (Huang *et al.*,2002).

2.4.8 Social benefits

Trees provide vital settings for recreation and relaxation in and near cities. The trees planted can contribute to social value, as communities tend to gather at places that have vegetation especially in city (Nurzaifah, 2013). The urban trees can enhance the conditions of those who live or work in cities. Viewing of trees from home or workplace provide peaceful experiences that can reduce mental fatigue and increase the level of concentration (Kaplan and Kaplan,1989). In contrast, being stressful for a long period of time can affect the human immune system. A series of studies show that views of nature reduce the stress response of both body and mind (Parsons et al., 1998). According to Tretheway and Manthe (1999), trees also reduce the exposure of ultraviolet light to human, thereby trees helps in lowering the risk of skin cancer and cataracts.

2.5 Species Diversity

The species diversity of the urban forest is much lower than natural forest. According to Barker and Tingey (1992), species diversity is important as it is believed to be the gene pool, population, communities and ecosystem with the ability to adapt and response to the environmental changes. The planting of mixed species of trees on the roadside of the city is definitely not a new concept, although, it is only now this matter has been considered seriously by the administration. Urban forestry literature generally suggests that any one species that will be planted must less than 10% of the total trees at that particular area (Richard, 1983).

Species diversity of urban trees depends on two factors which are the number of species and the evenness of all species in the population. It integrates both the richness of the group and

the evenness of the group distribution in a population. The tree population is weaker to the new stress environments, both abiotic and biotic if it has low species diversity.

2.6 Urban soil

According to Bockheim (1974), urban soil is a soil material having a non-agricultural, manmade surface layer more than 50 cm thick, which has been produced by mixing, filling, or by contamination of land surfaces in urban and suburban areas. Development activities made some patches of soil to have no top soil layer. Soil in urban area constitutes a wide range of materials, including natural, contaminated and degraded soils with several activities of substrates derived from industrial processes.

The soil nutrient riches and its capacity are useful factors for land use planning and management (Bullock and Gregory, 1991). However, urban soil status is much influenced by industrial activities which inevitably caused substantial soil contamination through extensive application of pesticides, herbicides, fertilizers and asbestos wastes (Bullock and Gregory, 1991).

In urban areas, apart from drought, plants are subjected to soil compaction (Craul, 1992). Thus, urban soil conditions can be difficult for root growth (Watson and Neelay, 1998) because nutrients are often limited under soil compaction and water stress. The impact of drought on ornamental plants is most serious after the plants are transplanted in the landscape (Craul, 1992). Urban soils have poor chemical quality and lack capacity to retain water. An evaluation of water economy of street trees in New York City, U.S., found that tree water deficits occurred less frequently than presumed and that water were more closely linked to high evaporative demand than to limited soil moisture (Whitlow *et al*., 1992).