Doctoral Thesis

Contextualizing Urban Biodiversity Conservation: Landscape Perception and Habitat-type Irreplaceability

(都市における生物多様性保全の概念化：ランドスケープ評価とハビタートの非代替性に着目して)

チュウ　ユ　ティング　ジョアン

Khew Yu Ting Joanne

ABSTRACT

The field of biodiversity conservation originated from the standpoint of minimizing human contact with relatively-pristine ecosystems. However, increasing habitat loss, and the realization that current protected areas are ineffective in halting species decline have cast spotlight on the possibility of utilizing urban areas for biodiversity conservation. Maintaining biological diversity in urban areas also allows for adequate niche-level redundancy to maintain or boost the benefits that urban-green spaces provide to humans (regulatory, cultural and to a certain-extent, provisioning ecosystem services).

In order to maximize conservation goals and ecosystem service provision in urban areas, the conservation success of red-list species can be used as an indicator for the conceptualization of biologically viable and ecologically contextualized native landscapes. Current urban red-list species conservation measures originate from developed countries in the global North and are broadly applied to cities throughout the world despite their unique socio-ecological characteristics. These measures promote red-list species conservation through increasing percentage land area allocated to "green-spaces" within urban areas, while simultaneously targeting a decrease in the degree of fragmentation of such spaces. Such practices work on the prevailing assumption that urban "green-spaces" (which usually refer to manicured landscapes) are uniformly effective for red-list species conservation in cities throughout the world. This thinking may prove problematic in cities where red-list species richness of natural and urban areas differs significantly.

Furthermore, there has been limited focus on how social perception of urban green-spaces fit together with conservation goals. Previous studies on urban biodiversity conservation have mostly been conducted from the ecological standpoint of quantifying general rural-urban species change or surrogate taxa studies. Research on the social perception of nature at a landscape level remains divided between elucidating that landscape preference is predominantly driven by either nature conservation attitudes, or scenic aesthetic appreciation. Therefore, though well-meaning, most current red-list species conservation policies tend to result in the creation of uniform urban landscapes that vary in social and ecological effectiveness by location.

This study aims to provide recommendations for the contextualization of green-space creation and red-list species conservation through consideration of the inter-relationships between the ecological and social factors of (1) habitat-type irreplaceability of red-list species and (2) landscape-level nature conservation intent and scenic aesthetic landscape preference (collectively termed as landscape perception) of urban dwellers. Cities chosen for analysis are three highly urbanized centers (population densities of more than 5,200 people per km^2): Singapore, Tokyo (23 Wards) and Vancouver. Although situated in different ecological zones [Singapore: Tropical, Tokyo (23 Wards): Warm Temperate; Vancouver: Cold Temperate], the three cities have adopted similar strategies for urban red-list species conservation. Consistent with initial measures originating from the global North, these strategies center on targeting a broad increase in manicured green-space cover.

The methodologies associated with the abovementioned aims are: (1) categorizing occurrence records of red-list species from five taxa (vascular plants, mammals, amphibians, reptiles and birds) according to terrestrial landscapes with varying degrees of human modification. (2) Random distribution of a landscape perception questionnaire quantifying the correlation between components of landscape perception (the intent to preserve nature at a landscape level and scenic aesthetic landscape appreciation) and respondent demographic factors. In addition a land-use analysis at the neighborhood scale on four randomly selected 0.3 x 0.3 decimal degree grids was conducted to ascertain differences in a typical urban dwellers' potential exposure to different types of green-spaces on a daily basis. Results would then be used to draw theoretical implications and practical recommendations for urban biodiversity conservation that are sensitive to the socio-ecological uniqueness of each study site.

Beyond this empirical aim, the results obtained in this thesis would be used to discuss the need for a 'mindset change' in conservation biology. From the outset of preserving relatively-intact natural areas, to the recent development of acknowledging urban areas as a fallback option for conservation and ecosystem service provision, urban biodiversity conservation has merely been seen as a back-up option to rural conservation efforts. However, this thesis aims to show that biodiversity conservation in socially accepted landscapes within urban areas is a feasible option. Furthermore, it can potentially become a powerful tool to re-connect humans with nature (and, subsequently, inspire a wider sense of environmental protection), when properly combined with an understanding of the way urban-dwellers perceive and appraise their surrounding landscapes.

Results of the categorization of post-2000 records of red-list species from five taxa in each study site reveal that Singapore, a tropical study site, was found to harbor the highest number of red-list species (1,116 species), followed by Tokyo (23 Wards) with 967 red-list species and Vancouver with 301 red-list species. Results also reveal a decreasing gap between the number of unique red-list species found in naturalistic landscapes (primary vegetation and secondary vegetation) and urban manicured landscapes in Singapore, followed by Tokyo (23 Wards), then Vancouver. 696 unique red-list species from the five investigated taxa can be found in naturalistic landscapes and not in urban landscapes in Singapore. This difference decreases to 211 red-list species in Tokyo (23 Wards) and 173 in Vancouver. Habitat-type irreplaceability of manicured landscapes and urban areas for all five taxa was found to exhibit the same pattern [0.329 in Vancouver, 0.310 in Tokyo (23 Wards) and 0.188 in Singapore on a scale of 0: completely replaceable to 1: completely irreplaceable]. Landscape types that were found to contain the highest conservation potential also differed between the three sites. The highest habitat-type irreplaceability value corresponded to a collection of natural and manicured landscapes in Vancouver (0.329), a combination of primary and secondary vegetation in Tokyo (23 Wards) (0.342) and primary vegetation in Singapore (0.360). The ecological analysis conducted in this study emphasizes that conservation of red-list species within manicured urban greens is comparably less effective in Singapore, followed by Tokyo (23 Wards), but is relatively effective in Vancouver. However, it also shows that urban areas hold promise for conserving at least a quarter (about 20%) of the total red-list species, even in tropical areas.

With regards to the social acceptance of landscape types which would contribute to maximal red-list species conservation in urban areas, findings of the landscape perception survey was not completely optimistic. Survey response rates were 29% (88/300) in Singapore, 16% (313/2000) in Tokyo (23 Wards) and 11% (110/1000) in Vancouver. Although respondents significantly valued the preservation of nature over its utilization regardless of location, landscapes that were widely preferred were not always those which supported maximal red-list species conservation. The majority of the respondents were found to significantly prefer visually non-complex landscapes. This resulted in manicured landscapes being increasingly preferred over naturalistic landscapes in the order of Singapore to Tokyo (23 Wards) to Vancouver.

Accordingly, Vancouverites exhibited a “best case scenario” whereby preferred landscapes coincided with landscapes with the highest habitat-type irreplaceability values (natural and manicured landscapes). Tokyoites’ and Singaporeans’ preferences were less consistent and inconsistent with habitat-types best suited for conservation (Tokyo: secondary and manicured landscapes; Singapore: manicured landscapes). From open-ended questionnaire answers and interview responses, reasons driving landscape selection were given to be predominantly aesthetic in all three cities, with the exception of Vancouverites citing biodiversity conservation as an additional motivator. Furthermore, results of a land-use analysis on the amount of manicured and naturalistic landscapes present at a neighborhood-level in the three study sites revealed no overall significant differences, thereby excluding *potential* exposure as an explanatory driver of landscape perception.

In summary, social and landscape results show that respondents in all three study-cities significantly value the preservation of nature over its utilization (landscape level) but have a landscape preference which is generally confined to visually non-complex landscapes. Therefore, there is a possibility that nature conservation intent functions less as a predictor of landscape preference than scenic aesthetics in tropical and warm temperate cities like Singapore and Tokyo (23 Wards). This could be due to the existence of a landscape "complexity preference limit" inherent in urban dwellers, where landscapes having too much biodiversity are deemed as visually chaotic and potentially unpleasant. The ecological results presented in this thesis highlights the natural baseline characteristic of extremely high red-list species-richness within natural tropical landscapes and the relatively lower species-richness in cool and warm temperate natural landscapes. Accordingly, across all three cities, preferred, non-complex landscapes were those that contain moderately high levels of unique red-list species (around 300 unique red-list species). However, this does not mean that conservation within default landscape preference is in conflict with ecological goals. In cold temperate cities (e.g. Vancouver), and to a certain extent, warm temperate cities [e.g. Tokyo (23 Wards)], non-complex habitat types included natural landscapes with significant habitat-type irreplaceability values.

The results of this study support city-specific social and ecological uniqueness. In accordance with prevailing social preference and habitat-type irreplaceability, it is easier to naturalize urban landscapes and conserve red-list species by default in Vancouver, as compared to Tokyo (23 Wards) and Singapore (most difficult). This result shows that current urban biodiversity conservation methods of increasing manicured landscape cover in cities can be effective in temperate zones but highlights the need for contextualized urban biodiversity conservation, especially in Singapore and Tokyo (23 Wards). Some recommendations are provided as follows:

A) Encourage a mindset change among policy-makers and practitioners towards realizing the potential of urban areas for conservation.
B) Maintain existing urban landscape aesthetics while increasing conservation capacity through micro-habitat modification especially in Singapore and Tokyo (23 Wards).
C) Consider the inclusion of non-invasive exotic species in non-complex landscapes insofar as they aid in the stabilization of microclimates. In some cases, non-invasive exotic species are already widely accepted by the general public [(e.g. Ginko trees in Tokyo 23 Wards)] and can be used as a focal point to increase acceptance of a more biodiversity city.
D) Encourage habitat-connectivity between parks and natural landscapes, instead of just between manicured landscapes.
E) Among survey respondents who indicated preference for both naturalistic and manicured landscapes, policy-targetable factors for increasing acceptance of naturalistic landscapes are conservation education in Singapore and encouraging frequent park-going behavior in Tokyo (23 Wards). A positive feedback spiral could then exist between promoting (A to E) and E as positive correlations were also found between experience of biodiversity, younger age, intent to preserve nature and naturalistic landscape choice. No significant correlating factors were found in Vancouver as the majority of respondents already had a preference for both naturalistic and manicured landscapes.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my supervisor, Professor Makoto Yokohari, for his guidance and support throughout this project. My gratitude goes once again to Professor Yokohari, Project Associate Professor Toru Terada, and Dr. Shogo Kudo for helping me in the preparation of the questionnaire used for the Tokyo (23 Wards) chapter of my thesis. I would also like to thank Project Assistant Professor Toshinori Tanaka and the members of the Forestry and Landscape planning laboratory, thank you for providing critical discussions which were invaluable in refining my project.

I would specially like to extend my gratitude to the members on my thesis committee: Professor Hirozaku Yamamoto, Associate Professor Motoharu Onuki, Associate Professor Akito Murayama, Project Associate Professor Hirotaka Matsuda and Project Associate Professor Toru Terada. Thank you for taking the time to provide me with guidance on deepening both the breadth and depth of this thesis.

I have relied on the help of many colleagues and counterparts, without whom, the successful distribution of the questionnaires used in this project would not have been successful. These individuals are: Mrs. Yola Lim and family, Ms. Dyah Fatma, Ms. Tiffany Chua, Dr. Victor Tumilba, Ms. Li Yawen, Ms. Tina Yamada, Ms. Inggita Utami, Mr. Jarkko Havas, Mr. Fan Haibo, Yaginumaさんand Ishikawaさん. The faculty and staff of GPSS-GLI and Associate Professor Toru Terada have also played a huge part in the completion of this project through their assistance in acquiring much-required project funds.

My gratitude also goes out to the interviewees involved in this project. Professionals and experts in their fields, they have provided me with their time and with valuable insights into the biodiversity conservation and landscape planning practice in Singapore, Tokyo and Vancouver. I would also like to thank the anonymous questionnaire participants in Singapore, Tokyo (23 Wards) and Vancouver for their time and patience.

A big thank-you goes out to all of the GPSS students, the '606 Royalties' and the 'GPSS-All Stars band'. I truly enjoyed the music, the intellectual and light-hearted conversations on ecology, philosophy, Tolkien, evolution, statistics and pop-culture; all of which helped me in one way or another. Without all of you, the time at GPSS would never have been the same. Also, I would like to make mention of Galneryus, Dethklok and Dream Theater, for their help (from a distance) in keeping me going.

Besides the groups and individuals mentioned, I recognize that there are still many others who have helped me through my years as a doctoral student. These individuals are too numerous to list here but are in no way any less important. Therefore, I would like to thank everyone who has have helped to just make a normal day better, through simple actions and words. These have all added up to drive home the point that sustainability (even on a daily basis) can be found in the maintenance of healthy inter-relations.

To sum this section up, I am very grateful to have an understanding and very supportive family who have always been there for me (including grandma, who was not able to see this thesis completed in person). Thank you for helping me in any way you all could. Thank you for visiting me in Japan and for believing in me. And finally, to a God who has seen me through everything, thank You.

<u>1. INTRODUCTION</u>

1.1 An urban perspective for biodiversity conservation

Biodiversity conservation is a long-established practice that has evolved alongside the field of natural resource management. Even before its formal establishment as an academic field at the First International Conference on Conservation Biology in 1978 (Van Dyke, 2008), people around the world have already been mindful of conservation at the species and habitat level. Notable examples include an edict given by Emperor Asoka in 252 BC, India, which covered the protection of animals, fishes and forests (Holdgate, 1999), the preservation of sacred *fengshui* forests in China's Song Dynasty (AD 960-1279) and the establishment of crown-forests in Medieval Europe (Van Dyke, 2008). From these examples, to the more common, well-known practice of creating nature reserves, a recurring theme in the field of biodiversity conservation has been the 'wilderness ideal' (Van Dyke, 2008). This theme puts forth the idea that pristine tracts of wilderness are the best landscapes for biological conservation and human intrusion on natural areas should therefore be kept to the minimum (Van Dyke, 2008).

Consistent with this ideal, the one of the first modern organization efforts was aimed at preventing the spread of urbanization to surrounding natural ecosystems (Guha, 2000). This task was taken up by the first organization for biodiversity conservation – the Commons Preservation Society (England, 1865). Subsequently, biodiversity conservation has been enacted through treaty-level protection of target species (e.g. Convention for the regulation of Whaling 1946, Convention on the Conservation of Migratory Species of Wild Animals 1979) and the creation of nature reserves (Miller and Hobbs, 2002; Van Dyke, 2008).

However, in light of the adverse impacts that a post-industrialized society has had on the natural environment, the extent to which the 'wilderness ideal' has been effective at achieving conservation goals is becoming increasingly questionable (McKinney, 2002; Miller and Hobbs, 2002). Studies by Grumbine (1990), McNeeley et al. (1994) and Newmark (1995) have found that the current total land area dedicated to nature reserves may be too small to be effective in halting species extinctions. Furthermore, the total area of built environments alone, excluding the land modified in light of anthropogenic impacts (i.e. the indirect effects of urbanization), exceed the total area allocated for nature conservation in countries such as the United States (McKinney, 2002) and Singapore (Yee et al., 2011). Considering a future trend of continual urbanization (United Nations, 2005), this situation may become quickly evident in throughout the world (Dearborn & Kark 2010; McKinney, 2002).

The realization that there are limits to the effectiveness of traditional conservation methods has gradually broadened the focus of conservation planning to include non-reserve areas like community forests (Jongman et al., 1995, Saunders et al. 1995). There has also been a small but notable shift, starting in the 21st Century, towards recognizing the biodiversity conservation potential of traditionally overlooked ecosystems, such as peri-urban and urban areas (Dearborn & Kark, 2010; Kühn et al. 2004; Rosenzweig 2003). These newer practices have demonstrated the need for the integration of human and natural systems in order biodiversity conservation to remain relevant (Miller & Hobbs, 2002). Accordingly, the urban landscape has been recognized as a fallback option for biodiversity conservation in pristine/ rural ecosystems.

Spearheaded by countries in Europe and the United States, urban biodiversity conservation through ecological landscape planning movements has become more commonplace throughout the globe (Forbes et al., 1997; McHarg, 1992). Leading ideas on urban biodiversity conservation have thus focused on increasing the area allocated for urban green-spaces with concurrent plans to limit the degree of fragmentation of these spaces. This has mainly been enacted through policies which increase connectivity between individual green-spaces within the urban fabric (i.e. through the creation of greenbelts). More often than not, these urban “green-spaces” are synonymous with manicured landscapes (Hostetler et al. 2011; The Biodiversity Conservation Strategy Partnership 2008; Biodiversity Strategy Office, Tokyo 2009).

1.2 Benefits of urban biodiversity conservation

The idea of utilizing urban green-spaces for biodiversity conservation runs contrary to the popular belief that urban areas are inhospitable to wildlife. However, the potential for biological conservation within the urban fabric is not a new discovery. Human settlements have traditionally developed in areas along rivers or coasts, with fertile soils and consequently, high biodiversity (Myers et al., 2000). As such, human settlements have long existed within all 35 biogeographic hotspots around the world (Myers et al., 2000).

Several recent studies have also lent support to the biodiversity inherent in urban areas. Research by Cornelis & Hermy (2004) has shown that urban forests in Flanders, Belgium may contain up to 60% of the country’s total number of plants, birds, butterflies and amphibians (Cornelis & Hermy, 2004). Vascular plant species richness was also found to be higher in the cities of Guangzhou, Christchurch and Berlin as compared to human-modified natural environments outside urban confines (Jim & Liu, 2001; Kűhn et al., 2004; Stewart, 2004).

In light of the strategic location of cities and the potential to harbor a significant amount of species diversity, conservation within cities is not only possible, but necessary both in itself and to increase the effectiveness of rural conservation by easing the patch-matrix effect between built areas and surrounding natural ecosystems.

Increasing flora and fauna diversity within cities also brings benefits to urban-dwellers. It is widely understood that urban green spaces contribute to human well-being through the provision of ecosystem services such as temperature-stabilization and pollution control (Daily, 1997; Chiesura, 2004). However, boosting species-richness within a city's ecological context is a step forward in safeguarding existing ecosystem services by increasing the resilience of green spaces. Higher species-richness increases the ecological niche redundancy within a given green space (i.e. having a higher variety of different species per ecological specialization). This increases the capacity of urban ecosystems to withstand pressures from external threats such as attacks by invasive pest species that target a particular species or ecological niche.

An example of such a case would be the (ongoing) attack of invasive emerald ash borers (*Agrilus planipennis*), an insect native to Asia, on native ash trees (*Fraxinus* spp.) in the cities of North America (Alvey, 2006). To date, it has been estimated that 15 million ash trees (widely planted for shade in urban areas) have been killed by the larvae of the emerald ash borer (Poland & McCullough, 2006). The larva bores deep into the tree, disrupting the flow of nutrients through the phloem tissues and causes tree death in just one to three years (Poland & McCullough, 2006). Despite efforts to contain the population of the emerald ash borer, the invasive pest has continued its spread from its first point of contact in Detroit, to other states in North America (Poland &

McCullough, 2006). Should the function of shade provision in the cities of North America have been spread out among a more biodiverse canopy, the damage caused by the emerald ash borer could have been reduced. Following this reasoning, aiming for biodiverse cities is an important goal in order to prevent future similar outbreaks that could end up reducing the ecosystem service provision capacity of urban green-spaces.

In ensuring adequate levels of biodiversity within urban confines, the conservation of red-list species functions as a key indicator in measuring progress towards this goal. A positive feedback loop exists between the presence of red-list species and overall biodiversity, and hence, resilience inherent in urban green spaces. Besides functioning as an indicator for general biodiversity(e.g. Thomas & Mallorie, 1985; Berg & Tjernberg, 1996; Gaston & Blackburn, 1996), the presence of red-list species may also actively promote biodiversity in green-spaces. An example of the latter case could be found in the predator-prey relationship between a red-listed snake [Kopstein's bronzeback snake (*Dendrelaphis kopsteini*)] and an exotic lizard [Changeable lizard (*Calotes versicolor*)] in Singapore (McCleary & Ichtiarani, 2005). It is hypothesized that the conservation of the Kopstein's bronzeback snake within urban parks could enable the comeback of the once-common native green crested lizard (*Bronchodela cristatella*), a species which has been displaced by the changeable lizard (McCleary & Ichtiarani, 2005).Should this food web be properly monitored and promoted, there would be a potential existence of three co-existing species by default, instead of just one dominant species. This example of a positive loop involving red-list species begetting even more biodiversity, might serve to increase the resilience of urban green-spaces through providing niche redundancy. Increased biodiversity within urban confines may also contribute to the mitigation of the divide between humans and nature (Pyle 1978, 1993).

1.3 The need for contextualization of urban biodiversity conservation practices

Despite the inherent capability of cities to support biodiversity, and the benefits that biodiversity provides for urban ecosystem service provision, conserving biodiversity in urban areas is challenging as it has to address the maintenance of the ecological integrity within social preference and economic boundaries. It has been mentioned in section 1.1, that much of the current urban biodiversity conservation measures applied in cities throughout the world are landscape-level practices that originate from developed countries in Europe and North America (Cillers et al. 2004). These measures promote biodiversity conservation through increasing the area allocated for urban green-spaces while limiting their fragmentation (The Biodiversity Conservation Strategy Partnership 2008; Biodiversity Strategy Office, Tokyo 2009; Hostetler et al. 2011).

The prevailing assumption underlying these practices is that urban “green-spaces” (which usually refer to manicured landscapes) are uniformly effective for red-list species conservation in cities throughout the world. However, adopting an increase in green-space cover as an across-the-board practice may not be as effective for biodiversity conservation in cities with wider structural and microclimatic differences between natural and urban areas. This could result in urban green-spaces of lower conservation quality within cities in the tropical belt (Chong et al. 2010; Shwartz et al. 2014). Furthermore, social acceptance regarding the degree of naturalization permitted within urban green-spaces may also differ depending on the scenic aesthetic quality of a country's given natural landscape (Khew et al. 2014).

There is therefore need for studies which promote a deeper understanding of the conservation potential of urban environments and its associated green-spaces in cities within different ecological zones (Shwartz et al. 2014). Ideally, these studies should also be discussed within the boundaries of social acceptance of nature and landscapes within urban environments. This is so that resultant urban biodiversity conservation practices would be socially acceptable and ecologically contextualized in order to maximize the resilience and provision of ecosystem services by green-spaces in urban areas.

1.4 Literature review and existing academic gaps

1.4.1 Ecological gap: Conservation potential of red-list species from multiple-taxas

The conservation potential of urban environments can be gauged through quantifying existing habitat specific species-richness (e.g. Bryant 2006; Shwartz et al. 2014). Species-richness change across habitats with varying levels of human modification or with varying connectivity to remnant natural vegetation can then contribute to decisions regarding the management and design of green-spaces to effectively carry out biodiversity conservation (e.g. Blair & Launer 1997; Zerbe et al. 2002). Furthermore, quantifying habitat-specific species-richness enables the determining of a site-specific conservation potential. This is done through calculation of a site-specific irreplaceability value, where high irreplaceability values mean that the site has species unique to it (Lawler et al. 2003).

Previous studies focusing on rural to urban species-richness change quantified general species-richness variation in birds, plants and butterflies within temperate countries such as Germany, France, United States and Canada (e.g. Clergeau et al. 1998; Zerbe et al. 2002). Studies on cities outside the temperate zone have been conducted on birds in Brazil (Reis et al.2002), on conservation-targeted birds in Israel (Shwartz et al. 2008) and on six conservation-targeted taxa in Singapore (Khew & Yokohari, in press).

All studies reveal an overall decrease in biodiversity and concurrent increase in habitat irreplaceability from landscapes with least to most human interference. However, only cities within the temperate zone display diversity gradients in accordance with the intermediate disturbance hypothesis where a peak in species-richness was found in suburban areas due to the increased heterogeneity of the landscape (e.g. Blair & Launer 1997; Zerbe et al. 2002). Although considerable ground has been covered by previous studies, most urban biodiversity conservation studies focus on one specific city and target a limited number of taxa. Exceptions are a study on endangered birds in Israel (Shwartz et al. 2008) and red-listed seed plants, ferns and fern allies, mammals, reptiles, birds and insects (excluding Lepidoptera) in Singapore (Khew & Yokohari, in press).

It is therefore arguable that there is a need for studies focusing on quantifying habitat irreplaceability in cities within different ecological zones, and with a specific focus on red-list species-richness. This is because red-list species are usually the focus of conservation policies and their numbers are positively correlated to the overall biodiversity in a given area (e.g. Thomas & Mallorie, 1985; Berg & Tjernberg, 1996; Gaston & Blackburn, 1996). There is also need for a multi-taxa focus in order to better understand if varying levels of human influence at a landscape scale affect different taxa in different ways (Shwartz et al. 2013).

1.4.2 Social gap: Nature conservation intent versus scenic aesthetics as drivers for landscape preference

In order to ensure continued policy success, garnering public support of the landscapes used for biodiversity conservation is as essential as ensuring robust ecological health of urban green spaces (Briffet, 1991; Leong, 2000). Public perception functions as a limit, or threshold level in determining the design and thus, indirect ecological function of green-spaces (Fischer & Young, 2007; Saito, 2007).

There have been considerable studies in the field of environmental psychology linking nature conservation intent to the degree of responsibility, connectivity and understanding a person has towards the biotic components of a landscape (see Schultz, 2000; Clayton, 2003; Frantz et al., 2005; Fischer & Young, 2007; Bruni & Schultz, 2010for examples). However, recent studies have suggested that these separate measurement categories can be grouped into two higher order factors: nature preservation and utilization (Khew et al., 2014; Milfront & Duckitt, 2004; Milfont & Gouveia, 2006) where nature preservation tendencies result in a preference for more naturalistic components in a landscape (Zagorski et al., 2004; van der Windt et al., 2007).

Usually, a tendency towards nature preservation can be derived through either experiential or educational exposure/ affinity to natural landscapes. van der Windt et al. (2007) studied nature and landscape preference among 35 people from three occupational groups in the Netherlands, asking respondents to rank landscape preference from descriptions of four landscapes with varying degrees of human interference. Findings revealed that respondents held different views on nature, reflected in landscape preference, depending on their occupation, with conservationists and officials preferring naturalistic landscapes. These results are similar to Zagorski et al.'s (2004) study, which found that gardeners who appreciated conservation tended to prefer native, naturalistic-looking gardens.

However, studies focusing on landscape preference as an independent factor suggest that in addition to a preference for nature preservation, scenic aesthetics could function as a decisive factor affecting how people valuate landscapes (Gobster 1999; Özgüner & Kendle 2006). A landscape which is described to be scenic is often not complex in appearance and has a high level of cohesion (Khew et al., 2014). Coherence, in turn, refers to the general "unity" of a landscape and can be increased by ordered patterns of color and dimension (Ode et al., 2009). A review by Parsons and Daniel (2002) has described a scenic aesthetic landscape preference as being evolutionarily ingrained in the universal human psyche.

Environments with low ground cover and ordered clumps of trees and shrubs arranged in a cohesive manner (e.g. savannah-like landscapes) were found to be preferred as it appeals to the basic human need of balancing resource availability and survival prospects (Kaplan & Kaplan, 1989; Orians & Heerwagen, 1992; Parsons & Daniel, 2002). This evolutionary driven landscape preference was found to be consistent across cultures around the world. Studies by Yang and Kaplan (1990) and Küller (1972) found similar aesthetic landscape preference among Koreans and Western groups and between Chinese and Swedish students respectively. The universality of this landscape preference has eventually found its way into art and have been propagated en-masse through the popularization of the 19th Century scenic aesthetic which involves emphasizing the panoramic and orderly components within natural landscapes (Gobster, 1999).

Savannah-like, visually ordered and picturesque landscapes are often a contrast to landscapes which inherently contain high biodiversity (e.g. a tropical rainforest) (Parsons & Daniel, 2002). In this context, the naturalistic landscapes selected by people with a pro-nature preservation preference would likely not be preferred by individuals selecting on the basis of scenic aesthetics (Parsons & Daniel 2002). Research by Herzog (1989), Jim and Chen (2006), Özgüner and Kendle (2006) and Bonnes et al. (2011) show that the general public in temperate and sub-tropical cities hold a neutral preference with regards to naturalistic landscapes and manicured/aesthetic landscapes. This is possibly due to the fact that these two landscape types do not differ drastically in appearance intemperate and subtropical environments. In these studies, natural landscapes were often represented by a forested scene with leisure spaces (e.g. a hiking path or a clearing) while manicured landscapes only differed in the representation of ornamental plants and more prominent urban features (e.g. buildings or a prominent public square) (Özgüner & Kendle, 2006; Caula et al., 2009).

In light of the divide between nature conservation intent and scenic aesthetic appreciation as separate drivers of landscape preference, there is need for studies which collectively consider the interaction between these two dimensions. Such integrated studies would serve to better understand how landscape preference is shaped and how it can be connected to practical steps in green-space naturalization in urban areas (Fischer & Young, 2007; van der Windt et al., 2007).

1.5 Research purpose

Despite the evidence that nature conservation intent and scenic aesthetic appreciation are potential effectors of landscape preference, it is still unclear how these social factors interact with each other. Furthermore, the level of cohesion in a landscape is strongly affected by the species richness inherent within the landscape (Bourassa, 1991; Ode et al., 2009). Higher habitat-specific species-richness is usually positively correlated with higher complexity and lower cohesion, thereby lowering the scenic aesthetic quality of a particular landscape (Bourassa, 1991; Khew et al., 2014). It is therefore important to consider how these separate indicators interact in order to fully understand how biodiversity conservation can be carried out in cities, within social acceptance boundaries. In summary, Figure 1 shows how nature conservation intent, landscape preference and habitat-specific species-richness influence each other on a conceptual level.

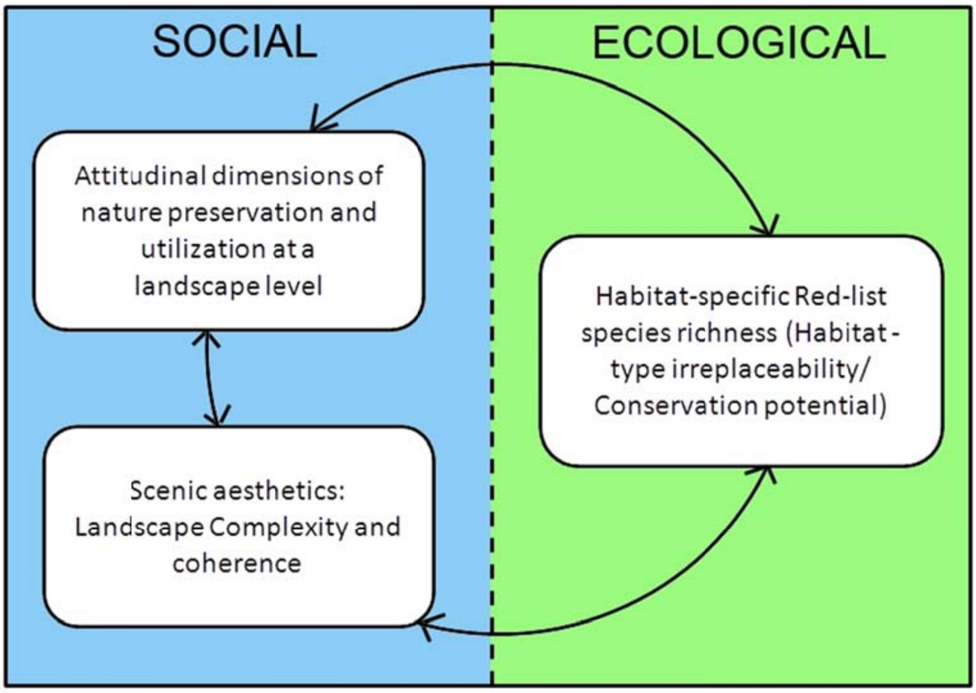


Figure 1: Conceptual connection between social and ecological indicators used for the contextualization of urban biodiversity conservation.

The purpose of this study is to utilize the abovementioned social and ecological indicators (Figure 1) to come up with holistic recommendations for the contextualization of green-space creation and red-list species conservation in three highly urbanized cities (population densities of more than 5,200 people per km^2): Singapore, Tokyo (23 Wards) and Vancouver. Although situated in different ecological zones [Singapore: Tropical, Tokyo (23 Wards): Warm Temperate; Vancouver: Cold Temperate].

The selection of these three sites are apt for the discussion of urban biodiversity contextualization as all three sites currently adopt similar strategies for urban biodiversity conservation. Consistent with initial measures originating from the global North, these strategies target a broad increase in manicured green-space (see section 1.3 for more details) . It is currently unknown if there are differing patterns of red-list species richness change across landscape types of varying human influence in these three study sites. Also, despite a global trend of increasing environmental concern, it is unclear if such sentiments are translated to positive conservation intent for nature at a landscape level, and if they are subsequently reflected in landscape preference. This is especially relevant in the context of the three study sites where there are significant differences in the aesthetic appearance of landscape types within tropical, warm temperate and temperate cities.

Therefore, resultant ecological and social indicators selected for the contextualization of urban biodiversity conservation in each study site focuses on: (1) quantifying landscape-level nature conservation intent and landscape preference (collectively termed landscape perception) of urban-dwellers, as well as investigating underlying demographic preference drivers, (2) profiling red-list species richness by terrestrial habitat type with consideration of habitat-type irreplaceability and subsequently, (3) providing recommendations for conservation of red-list species in urban areas that are sensitive to the socio-ecological uniqueness of each study site.

Therefore, the results of study would contribute to elucidating the relation between nature conservation intent, scenic aesthetic landscape preference and the amount of red-list species-richness inherent in landscapes with different degrees of naturalness in Singapore, Tokyo (23 Wards) and Vancouver. It would also aid in the understanding of the type of urban nature required to maintain a biodiverse and socially acceptable environment in the three study sites, and the cultural factors driving such a preference.

1.6 Summary

In summary, this chapter aims to put forward the following points:

A) Section 1.1: Traditional biodiversity conservation methods in rural areas are inadequate as there are insufficient protected areas to prevent further species loss.

B) Section 1.2: Urban areas are needed as a complimentary means for conservation. This is due to cities being situated within biogeographical hotspots, harbouring a significant amount of biodiversity and providing regulating, provisioning and cultural ecosystem services to urban dwellers. In terms of finding a reliable measure for urban biodiversity, red-list species are a good indicator for wider diversity and may even contribute to the maintenance of biodiverse urban green-spaces through promoting inter-species competition.

C) Section 1.3: Current urban biodiversity conservation methods have originated from developed countries in the global North and are widely spread throughout the world.

There is therefore need for contextualizing these methods in accordance to socio-ecological uniqueness of a city.

D) Section 1.4.1: To date, much research on the ecological component of urban biodiversity conservation is focused on single-taxa studies on general rural-urban species gradient or finding diversity correlates with other taxa. There is need for more studies focusing on quantifying habitat-type irreplaceability with a specific focus on red-list species-richness from multiple taxa.

E) Section 1.4.2: The ecological component of urban biodiversity conservation (Section 1.4.1) has not been well integrated with the social landscape perception indicators, which are important in determining the degree by which landscapes are naturalized in cities. Furthermore, there has been contrasting evidence that both nature conservation intent and scenic aesthetic appreciation are potential effectors of landscape preference.

F) Section 1.5: In light of the academic gaps presented in section 1.4.1 and 1.4.2, this study aims to provide recommendations for the contextualization of green-space creation and red-list species conservation through consideration of the inter-relationships between the ecological and social factors of (1) habitat-type irreplaceability of red-list species and (2) landscape-level nature conservation intent and scenic aesthetic landscape preference (collectively termed as landscape perception) of urban dwellers. Cities chosen for analysis are three highly urbanized centres (population densities of more than 5,200 people per km^2): Singapore, Tokyo (23 Wards) and Vancouver. Although situated in different ecological zones [Singapore: Tropical, Tokyo (23 Wards): Warm Temperate; Vancouver: Cold Temperate], the three cities have adopted similar strategies for urban red-list species conservation. Consistent with initial measures originating from the global North, these strategies centre on targeting a broad increase in manicured green-space cover.

2. MATERIALS AND METHODS

2.1 Study sites

The case study sites chosen in this study, Singapore, Tokyo (23 Wards) and Vancouver, are urbanized cities in developed countries situated within different ecological zones. Singapore has been classified as a tropical city, while Tokyo (23 Wards) has a warm temperate climate and Vancouver is located in the temperate ecological zone (Peel et al., 2007; FAO, 2014) (Figure 2).

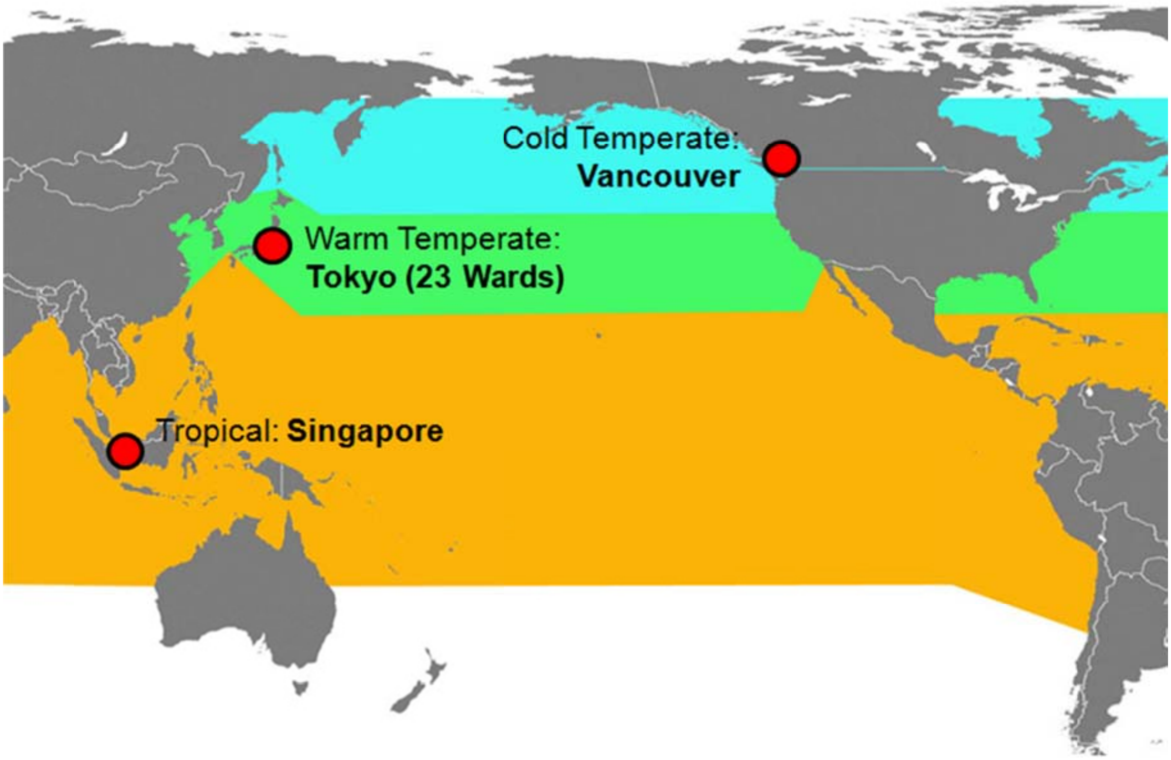


Figure 2: Case study cities within their respective ecological/ climatic zones as classified by Peel et al. (2007) and the Food and Agricultural Organization (2014).

Population densities of the three case study sites are all higher than the consensus definition for "urban areas" according to the 2,590/ km^2 stated by the United States Census Bureau (2010) or the 1,500/ km^2 stipulated by Eurostat (2011). The population density of Singapore is recorded to be 7,618/ km^2(Statistics Singapore, 2014)while the population density of Tokyo (23 Wards) is about 14,849 / km^2(Tokyo Statistics Division, Bureau of General Affairs, 2015) and population density of Vancouver is recorded to be 5,249/ km^2 in Vancouver (Statistics Canada, 2012).

As mentioned in Section 1.5, the selection of these three cities is apt for the discussion of urban biodiversity contextualization. All three study cities are situated in countries that have committed to urban biodiversity conservation. Singapore and Japan are signatories to the Convention of Biological Diversity (Singapore and Japan), while Canada is a member of the Local Governments for Sustainability, which has a heavy focus on urban biodiversity protection .All three cities also have a common method of conserving urban biodiversity through increasing urban green-space (i.e. manicured park) cover and/or reducing the degree of fragmentation between individual parks (The Biodiversity Conservation Strategy Partnership, 2008, Biodiversity Strategy Office, Tokyo 2009, Ministry of National Development, Singapore, 2013). This is consistent with the initial urban biodiversity conservation measures originating from developed countries in Europe and the United States (Cillers et al., 2004).

The highly urbanized nature of Singapore, Tokyo (23 Wards) and Vancouver, taken in conjunction with plans to increase the area dedicated to manicured parks within the urban fabric has resulted in land-use patterns in which more than 50% of the city area is dedicated to urban (non-vegetated) and manicured landscape (park) use (Figure 3 to 5).

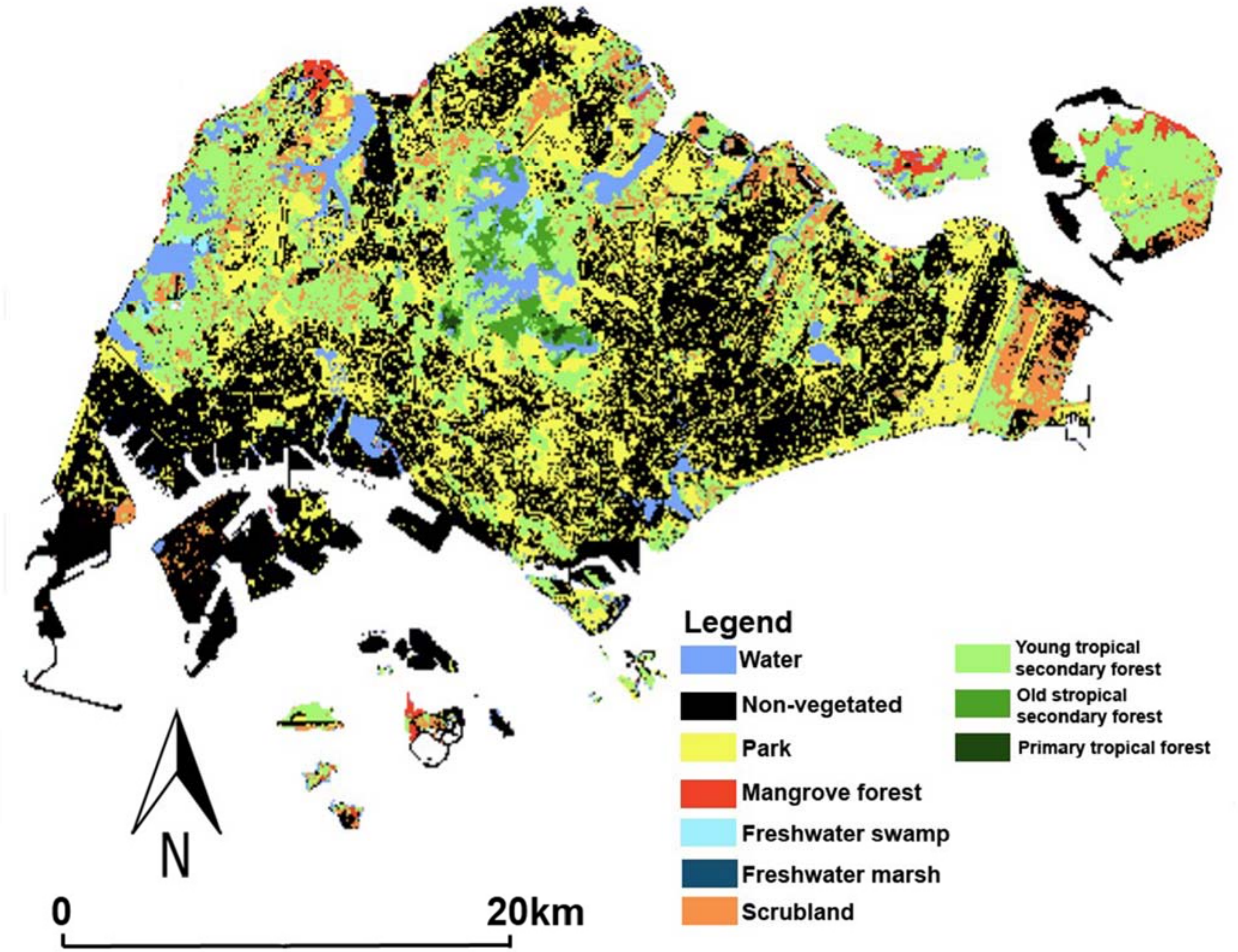


Figure 3: Land use map of Singapore (2011) adapted from Yee et al. (2011).

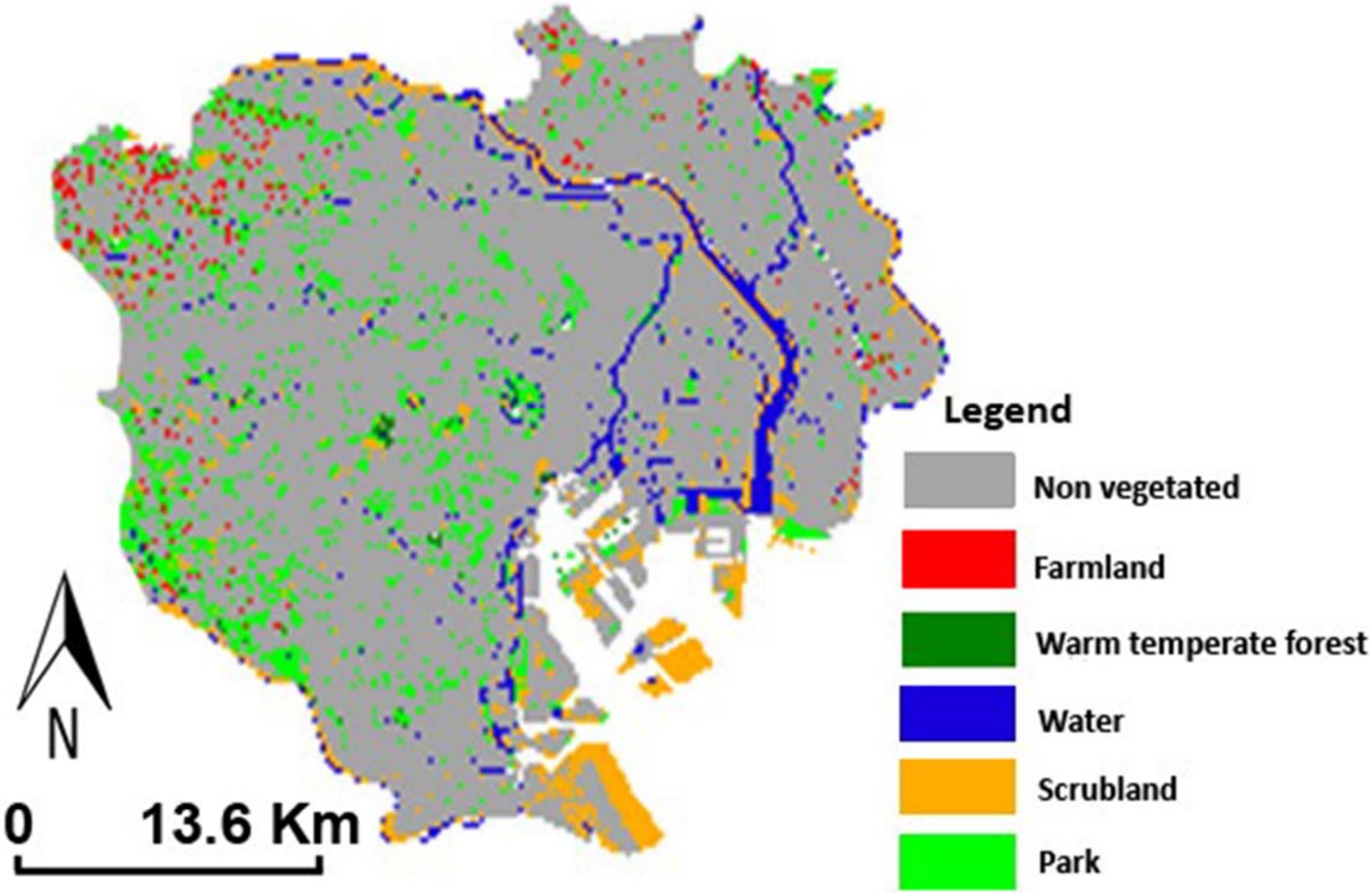


Figure 4: Land use map of Tokyo (23 Wards) (1998), adapted from 東京都環境局 (2003).

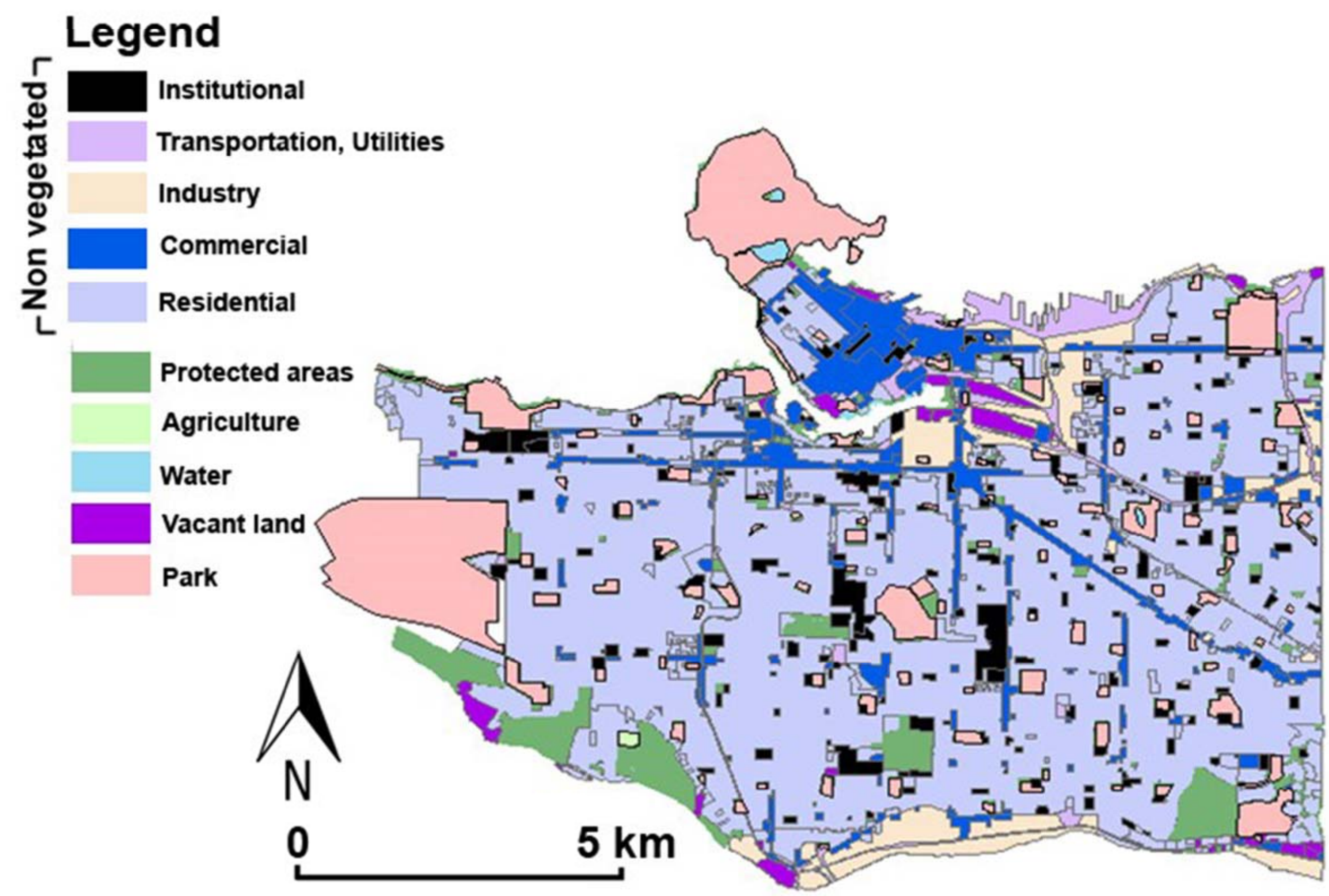


Figure 5: Land use map of Vancouver (2006), adapted from Simon Fraser University (2006).

Despite the uniformity of urban biodiversity conservation methods in Singapore, Tokyo (23 Wards) and Vancouver, these three sites contain natural and manicured vegetation unique to tropical, warm temperate and cool temperate biomes. It is currently unknown if there are differing patterns of red-list species richness change across landscape types of varying human influence in these three study sites. Also, despite a global trend of increasing environmental concern, it is unclear if such sentiments are uniformly translated to intent for nature preservation at a landscape level, and if this intent is consistent with a scenic aesthetic landscape preference. As such, there is need to examine if current uniform methods of conserving urban biodiversity by increasing manicured green space cover in all three cities are a good fit with conservation goals and the social preference of urban dwellers in each study site. Subsequently, this would open up an avenue for discussion on how to contextualize urban biodiversity conservation according to the ecological and social uniqueness of each city.

2.2 Summary of methods used in accordance with research purposes

As mentioned in section 1.5 of this thesis, this thesis aims to discuss the need for contextualizing urban biodiversity conservation using city-specific social and ecological indicators. The indicators selected for analysis are the ecological indicator of habitat-type irreplaceability of red-list species and the social indicators of landscape-level nature conservation intent and scenic aesthetic landscape preference (collectively termed as landscape perception) of urban dwellers. These indicators were quantified for each of the study sites [Singapore, Tokyo (23 Wards) and Vancouver].

A summary of the methodology employed in this thesis to measure the selected ecological and social indicators is provided in Table 1. Results of the social and ecological indicators would be used to come up with theoretical and practical recommendations for conservation of red-list species in urban areas that are sensitive to the socio-ecological uniqueness of each study site.

Table 1: A summary of the ecological and social indicators used in this thesis and their associated methodology. These methods were applied to each study site [Singapore, Tokyo (23 Wards) and Vancouver].

Indicator	Methodology
Ecological **(see section 2.3for details)** Habitat-type irreplaceability of red-list species (Conservation potential of urban landscapes)	• Quantifying habitat-type irreplaceability of landscape types along a gradient of human modification was accomplished using red-list species from five taxa (vascular plants, mammals, amphibians, reptiles and birds) as indicators. • City-specific occurrence records of red-list biodiversity from 2008 (or later) were obtained through National Red Data Lists. • Available landscape types were obtained from official vegetation maps for each city.
Social **(see section 2.4 for details)** 1. Landscape-level nature conservation intent 2. Scenic aesthetic landscape preference	• The primary means of quantifying the social indicators in this thesis was through a randomly distributed questionnaire. • 1. Landscape-level nature conservation intent: Questions corresponding to six first-order dimensions measuring different aspects of human-nature interaction (e.g. from scientific understanding to emotional connection) on a Likert scale was utilized. Answers can be regressed to two second-order factors of either nature preservation or utilization at a landscape scale. • 2. Scenic aesthetic landscape preference: Respondents selected any pictorial combination of landscape types available in each study site (for a future urban scenario, and for their ideal construct of "nature"). These landscape types were identical to those used in the ecological quantification and are based on available vegetation present in each study site.
Supporting indicators 1. Landscape indicator (see section 2.5 for details) Urbanites' potential daily exposure to natural landscapes 2. Political/ academic relevance of recommendations (see section 2.6 for details)	• 1. Land-use and land-area analysis on four randomly selected 0.3 x 0.3 decimal degree grids in each study site from satellite images (2015) • 2. Open-ended interviews with five personnel in Singapore and three personnel in Vancouver who are involved in biodiversity conservation and landscape planning.

2.3 Ecological factor

2.3.1 Red-list species categorization in Singapore, Tokyo (23 Wards) and Vancouver

Red-list species are a special subset of the total global flora and fauna diversity. The International Union for Conservation of Nature (IUCN) defines these species as those which are classified as vulnerable, endangered or critically endangered based on indicators such as population trends (size and structure) and active range (IUCN, 2015). As such, red-list species are determined to be most in need of conservation attention due to eminent extinction threats. Red-list species were selected as an indicator for the conservation potential of landscapes/ landscape groups in Singapore, Tokyo (23 Wards) and Vancouver as these species are most affected by land-use change (Davidson et al. 2008) and are good umbrella-species for wider biodiversity protection. Even between different taxa, the species-richness of vascular plants and birds (and possibly, red listed species comprising these two taxa) have also been recognized to be good surrogate taxas of general species-richness in urban environments (Duelli & Obrist 1998; Sauberer et al. 2004).

To date, the IUCN remains the global authority on assessment of species extinction threats and is utilized by many governments in setting national conservation goals (IUCN, 2015). It is also the guiding principle in measuring progress towards conservation goals set in the Aichi Targets of the Convention of Biological Diversity (IUCN, 2015).

As signatories to the Convention of Biological Diversity, Singapore and Japan have adopted the IUCN classification method for the determination of red-list species, albeit at the national level (Davidson et al., 2008; JIBIS, Undated). Canada, on the other hand has its own method for identifying its “red-list” species. Utilized mainly within the United States and Canada, the NatureServe Classification system is employed to assess species which are in need of conservation (BC Species and Ecosystem Explorer, 2013). The NatureServe Classification system is used to guide conservation goals for the United States Endangered Species Act’s and the Canadian Wildlife Service’s Species at Risk Act (NatureServe, 2015).

As the IUCN and NatureServe Classification systems have developed independently there are minor differences inherent in their respective criteria. Similarities and differences between these two categories in terms of determining if a species requires conservation attention (at the level of the most conservative estimate) are shown below (IUCN, 2015; NatureServe, 2007):

1. Both the IUCN and NatureServe classification assess a species as threatened if it shows a significant population size reduction over three breeding generations.
2. Both the IUCN and NatureServe classification assess a species as threatened if it has a current population of 1,000 individuals or less, in a given location.
3. The IUCN classification puts more weight, in comparison to the NatureServe Classification to assessing the probability of extinction in the wild to 10% or more of the current species population over the next 100 years.
4. The NatureServe classification puts more weight, in comparison to the IUCN classification to assessing the geographic range reduction (< 20,000 Km^2 for extent of occurrence and < 2,000 Km^2 in area of occupancy) of a specific species.

Despite minor weighting differences, both the IUCN and NatureServe classifications have been scientifically accessed to be similar in determining if a species requires conservation aid (Master et al., 2012; NatureServe, 2015). As such, species which are labeled as “vulnerable” in accordance to the IUCN red-list assessment are determined according to a very similar assessment method which labels species as “imperiled” under the NatureServe classification system. Species which are labeled as “endangered” and “critically endangered” under the IUCN red-list assessment method are assessed in a similar way as species which are labeled as “critically imperiled” under the NatureServe classification system (Master et al., 2012).

In this thesis, “red-list” species are taken to mean species which are classified as “vulnerable”, “endangered” and “critically endangered” under the IUCN red-list assessment system (for Singapore and Japan) and species which are classified as “critically imperiled” under the NatureServe Classification system. For simplicity, conservation status of the species mentioned in this thesis would be referred to according to the IUCN’s classification terminology.

In order to narrow down red-listed species which are present specifically within the urban confines of Singapore, Tokyo (23 Wards) and Vancouver individual occurrence records tagged to each red-list species were researched and checked for presence/absence within the vegetation present within the three study cities. More details regarding this methodology can be found in sections 2.3.2 of this thesis.

2.3.2 Species-richness by habitat type, selection of habitat types and red-list species

Assessment of species-richness per habitat type was carried out for red-list species in the three study sites for five biodiversity taxa (vascular plants, mammals, amphibians, reptiles and birds). These categories were chosen in lieu of data exhaustiveness, reliability and availability. Conservation status of individual species was obtained through post -2000 Red Data List records in Singapore, Japan and British Colombia (Davidson et al., 2008; J-IBIS data published from 2012-2013 records; BC Species and Ecosystem Explorer 2013).

Occurrence records of all red-list species were then obtained from the IUCN database, The Digital Nature Archive of Singapore, Singapore Vascular Plants Archive, British Columbia Conservation database, J-IBIS (Japan Integrated Biodiversity Information System), ESABII (The East and Southeast Asia Biodiversity Information Initiative) Database and the EOL (Encyclopedia of Life) Database. If the record for any species showed up in more than one database, occurrence records were summed. Summation of species occurrence records for the purpose of conducting a review analysis of species richness has been also conducted in review studies on species richness in urban parks (e.g. Fernandez-Juricic & Jokimäki, 2001; Hernandez et al., 2009; Nielsen et al., 2013), and general trends in the field of urban biodiversity (McKinney, 2002).

Species which had occurrence records in non-terrestrial habitats and which were considered to be located out of the habitat range of the study cities according to land-use data taken from: Okutomi (1979) (Tokyo, 23 Wards), Yee (2011) (Singapore), and the Metro Vancouver Sensitive Ecosystem Inventory (SEI) (2014) were not considered for inclusion in this thesis (Table 2).

Table 2: Habitats recorded in the occurrence records of conservation-targeted species and resultant grouping of recorded habitats on a human modification scale.

Study site	Recorded terrestrial habitats	Recorded non-terrestrial habitats and habitats out of study site range	Gradient of habitats considered in this study, on a scale of least (1) to most (6) human modification[1]
Singapore	1. Primary Vegetation 2. Secondary Vegetation 3. Urban green-spaces/ Manicured landscapes 4. Urban areas (including Roadside plants and ditches)	Non-terrestrial Habitats 1. Mangrove swamps 2. Marine habitats 3. Freshwater swamp forest	1. Primary Vegetation 2. Secondary Vegetation 3. (No available habitat type) 4. (No available habitat type) 5. Urban green-spaces/ Manicured landscapes 6. Urban areas(including Roadside plants and ditches)
Tokyo (23 Wards)	1. Primary Vegetation 2. Secondary Vegetation 3. Agriculture landscapes (including rice paddies) 4. Urban green-spaces/ Manicured landscapes 5. Urban areas (including Roadside plants and ditches)	Non-terrestrial Habitats 1. Mangrove swamps 2. Marine habitats Habitats out of study site range[2] 1. Habitats in Ryukyu Islands/ Tropical ecosystems/ Okinawa 2. Alpine ecosystems/ tundra at elevations of higher than 1000 metres above sea level	1. Primary Vegetation 2. Secondary Vegetation 3. (No available habitat type) 4. Agriculture landscapes (including rice paddies) 5. Urban green-spaces/ Manicured landscapes 6. Urban areas (including Roadside plants and ditches)
Vancouver	1. Primary Vegetation 2. Secondary Vegetation 3. Grassland 4. Agriculture landscapes 5. Urban green-spaces/ Manicured landscapes 6. Urban areas (including Roadside plants and ditches)	Non-terrestrial Habitats 1. Ocean habitats 2. Open water/ freshwater lakes/ Bogs Out of study site range[3] 1. Alpine ecosystems/ tundra at elevations of higher than 1000 meters above sea level.	1. Primary Vegetation 2. Secondary Vegetation 3. Grassland 4. Agriculture landscapes 5. Urban green-spaces/ Manicured landscapes 6. Urban areas (including Roadside plants and ditches

[1]The ordering of habitats along a human modification gradient was inferred in reference to similar studies conducted by Blair (1999), Shwartz, et al. (2008) and Reis et al. (2012).
[2]Okutomi (1979).
[3] Metro Vancouver SEI records (2014)

The remaining six relevant habitat-types [1. primary vegetation, 2. secondary vegetation, 3. grasslands, 4. agriculture landscapes, 5. urban green spaces/ manicured landscapes and 6. urban areas (including roadside plants and ditches)] were taken as independent factors in quantifying species-richness in study sites. These habitat types were ranked on a scale of human modification with primary/ old secondary vegetation being the habitat with the lowest level of human modification and urban areas having the highest level of human modification (Blair, 1999, Shwartz et al,. 2008, Reis et al., 2012).

2.3.2 Habitat-type irreplaceability

Habitat-type irreplaceability was inferred from habitat specific species-richness, by quantifying red-list species, instead of habitat-type, as an independent factor in classifications. Doing so would prevent the counting of any species more than once for the combination of habitats that they were found to occur in. For example, if a species was found to occur in a combination of primary/ old secondary vegetation and secondary vegetation, it would be considered unique to the primary and secondary vegetation category, and not counted once in the primary vegetation habitat and once again in the secondary vegetation habitat.

The habitat classifications used for synthesis of habitat-type irreplaceability results were based on both on their existence in red-list species occurrence records and their existence within the relevant terrestrial habitat types considered in this review (Table 2). A species was excluded if it was found to occur exclusively in a habitat type not considered in this review, or if it was found to occur in a combination of habitat types that included habitats not considered in this review. This is due to the uncertainty in determining the degree of dependency on any given habitat within a combination of habitats that a species was reported to occur in. Habitat irreplaceability values were subsequently calculated as a percentage (0 - 1) of the number of species unique to the specific habitat, or a specific habitat combination, within the entire dataset of each study site. A habitat irreplaceability value of 1 correlates with a high conservation value as it means that the habitat is entirely comprised of species unique to it.

2.4 Social factor: Landscape perception questionnaire design

Public perception of nature in relation to landscape preference was quantified through the administration of a 45 question questionnaire in Singapore and a shortened version of the same questionnaire (34 questions) in Tokyo (23 Wards) and Vancouver. All versions of the questionnaires had a non-compulsory final question which was designed for feedback collection. The shortened version of the questionnaire was considered equally reliable as its longer counterpart in lieu of the questions having identical meaning, and having an equal distribution among the dimensions used to quantify nature conservation intent and landscape preference. As such, the shortened questionnaires would have the same reliability as the longer version used in Singapore (please see section 2.4.1 for more information on pre-questionnaire reliability testing).

The questionnaires were divided into three sections which quantified respondents' demographic information, targeted the quantification of conservation intent with regards to natural landscapes and their biotic component and which quantified respondents landscape preference. All versions of the questionnaires collected demographic information of survey respondents pertaining to the following independent variables: 1) age, 2) sex, 3) nationality 4) occupation, 5) experience of staying in a foreign country for more than two years, 6) [only in Tokyo (23 Wards) and Vancouver], experience of staying outside the main city for more than two years, 7) frequency of exposure to nature-related activities independently (e.g. visits to parks or nature reserves) or in an environment-related organization and 8) instances of taking ecology/ conservation-related courses.

Factors 5), 6) and 7) were included as possible indicators towards respondents' degree of exposure to non built-up areas (with regards to factor 6, this reasoning would be applicable to countries which have abundant and easily accessible non-urbanized areas), which could in turn affect how respondents perceive nature and their landscape preference (Burgess et al., 1988; Henwood & Pidgeon, 2001). The inclusion of Factor 8) was in light of studies which have shown a positive correlation between scientific knowledge regarding conservation and nature conservation tendencies (Caro et al. 1994).

In the context of this thesis, only responses from citizens and permanent residents of each study site were considered. This is because these two groups of people have potentially more leverage (as compared to foreign residents) in making decisions with regards to nature and landscape policies in their respective cities (Choo, 2011; Soh & Yuen, 2006). As such, nationality was not used as an independent factor in the questionnaire analysis.

The exclusion of income as a demographic factor in this questionnaire was also due to inconsistencies in trends correlating income and tendency for nature preservation. Some studies have demonstrated a positive correlation between income and willingness to preserve nature (Kellert, 1994; Pouta et al., 2000). Explanations for this trend hinge on the arguments that financially well-off individuals have their basic needs, and hence have the luxury of time and resources to care about extended issues such as the protection of nature (Van Liere & Dunlap, 1980). However, opponents to this trend argue that people from lower income groups would show a higher tendency to preserve nature instead as they would probably have experienced living in areas with poor environmental surroundings and hence, are more likely to work towards a future with better environmental conditions (Buttel & Flinn, 1974).

The second section of the questionnaire contained 36 questions from six first order dimensions corresponding to how people would relate to natural landscapes and its biotic components. These dimensions were selected to quantify multi-faceted responses in terms of the degree of emotional, scientific, experiential connection a person would feel towards nature (e.g. Schultz, 2000; Clayton, 2003; Frantz et al., 2005; Fischer & Young, 2007; Schroeder, 2007; Bruni & Schultz, 2010). Table 3 shows a detailed description of the dimensions used to quantify nature conservation intent in the questionnaire.

Table 3: Dimensions used in the questionnaire to quantify public perception towards either preservation or utilization of nature.

Second-order factor	First-order factor	Dimension	Definition
Preservation	P1	Experiential enjoyment of nature	Perception that time spent in a natural landscape is more enjoyable/ pleasant than time spent in urban/ built-up areas.
	P2	Pro-conservation behavior	Readiness to support natural landscape and biodiversity conservation (regardless of resultant human benefit) directly or indirectly through means such as providing monetary or policy support.
	P3	Emotional (ecocentric) concern	Perception that loss of natural landscape and its biotic components would also result in emotional loss.
Utilization	U1	Pro-conservation behavior motivated by human benefit	Perception that nature should be conserved insofar as conservation has human benefits.
	U2	Dis-connect with nature	Perception that humans are superior to other forms of nature and that nature exists primarily for human use.
	U3	Utilizing/ altering nature for human gain	Perception that humans have the right to modify natural landscapes to suit their comfort and needs.

The first-order dimensions would ultimately be regressed to two second order factors which measure a respondent's intent to either preserve or utilize nature at a landscape-level (Milfront & Duckitt, 2004). The questions were designed based on an analysis of available questions from previous studies on environmental attitudes (Caro et al., 1994; Chua et al., 2008; Milfront & Duckitt's, 2010) and contextualized to fit the study site. This section of the questionnaire was shortened to 22 questions in Tokyo (23 Wards) and Vancouver in order to minimize redundant questions (see section 2.4.1 for more details). The questions used in this portion of the study can be found in Appendix B.

The last section of the questionnaire contains two questions which targeted respondents' landscape preference through the use of pictures depicting terrestrial landscapes in each study city with different degrees of human modification (Figure 6). The varying degrees of human modification are visually detectable in the landscape selection provided and also correspond to indicators of ecological species-richness and scenic aesthetics (i.e. higher visual complexity and lower coherence reflected in landscapes which have a higher effect of human management). The use of pictorial aids in preference surveys is a practiced method which can accurately access respondents' response to the actual landscape type portrayed (e.g. Hull & Stewart, 1992; Ode et al., 2009).

Figure 6: Pictorial landscape choices presented for the questions on landscape preference in Singapore, Tokyo (23 Wards) and Vancouver. These terrestrial landscapes were selected on a gradient of visually detectable human modification and were consistent with terrestrial habitats recorded in the occurrence records of red-list species (Table 1).These landscapes also present distinct levels of species richness and visual coherence and complexity (proxy for scenic aesthetics). Respondents were able to select any combination of landscape types in the landscape preference section of the questionnaire.

The landscapes presented in this portion of the questionnaire corresponded with the terrestrial habitats recorded in the red-list species occurrence records (see table 1, section 2.3.1). Respondents were asked to select any combination of landscapes as presented in Figure 3 in response to two questions: 1) landscapes which they feel, fit their definition of an ideal construct for "nature" and 2) landscapes which they feel should be represented more in the urban area in the future.

2.4.1 Pre-testing and determination of optimal sample sizes

A preliminary version of the questionnaire, with 36 questions quantifying all six dimensions corresponding to natural landscape conservation intent, was administered to 25 students in the Graduate Program in Sustainability Science, The University of Tokyo in January 2012. The sample size of 25 allowed for the determination of close to 90% probability that consistency and phrasing problems would be detected in the questionnaire (Perneger et al., 2015). The questionnaires were checked for internal consistency within all six scales measuring perception of nature (Table 3). Each measurement scale had a Conbrach's Alpha score of more than 0.7 [IBM Statistical Package for Social Sciences (SPSS V19)] and were thus deemed reliable.

A slightly modified version of the preliminary questionnaire (the wording of the question was slightly changed for clarity) was then administered to 20 members of the general public in Singapore during February, 2012 and checked again for internal consistency and ease of understanding. This sample size was again more than the minimum of 15, required to achieve close to 90% probability of error detection (Perneger et al., 2015). This step was taken to re-test the modified questionnaire and ensure its relevance to the general population (and not only to graduate students). All six dimensions again were had a Conbrach's Alpha score of more than 0.7.

The results of this final questionnaire were utilized for the determination of sample sizes required for the actual questionnaire administration. Ideal sample sizes were calculated with the aid of the PS: Power and Sample Size Calculator, a freeware developed by the Department of Biostatistics, Vanderbilt University (Dupont & Plummer, 1990). The assumption used in this test was that preservation intent for scores would be significantly higher than utilization intent for the 36 questions corresponding to the six dimensions of nature conservation intent. Another assumption was that final questionnaire distribution conditions would be similar to the second pre-test: random distribution to the general public. Results revealed that, in lieu of the high consistency of the questions, a minimum sample of 85 respondents was required at a predictive power of 0.90.

2.4.2Questionnaire distribution

In Singapore and Vancouver, final versions of the questionnaire were distributed randomly to 300 households in the former city and 1,000 households in the latter. Survey distribution in Singapore took place from in March, 2012 and survey distribution of Vancouver took place during November, 2014. Distribution in Tokyo (23 Wards) was carried to 2,000 households out using a stratified-random approach during June, 2014. The questionnaires were targeted at citizens and permanent residents of Singapore, Japan and Vancouver respectively. This is because this group of individuals have the highest potential to influence decisions on urban planning and hence, biodiversity conservation within urban confines.

During the survey distribution in Singapore, the map of the mainland Singapore was divided into 46 equal sized grids and 10 girds were selected with the aid of a random number table. Questionnaires were hand-placed into mailboxes of 30 random residential units in grid.A variation of this method was employed in Vancouver, where addresses of the residential white pages (available online) were randomized and 1,000 households were selected to receive the questionnaire through mail.

A slightly different, stratified-random sampling method was employed for questionnaire distribution in Tokyo (23 Wards). In this method, four wards were selected (Sumida-ku, Nerima-ku, Katsushika-ku and Nagano-ku) and questionnaires were randomly distributed to 2,000 households within these wards, using a random-grid selection process. This method was employed in order to ensure that the questionnaires reached the maximal number of Japanese citizens as possible. According to the Ministry of Internal Affairs and Communication's National Census (2010), the four selected wards had the highest population of Japanese nationals and were therefore chosen for sampling.

In all three cities, return postage-paid envelope was included in the survey package and participants were asked to mail the completed surveys back to the researcher after a period of maximum, three weeks from the time they received the questionnaire.

2.4.3 Statistical analysis

Data obtained the landscape perception questionnaire were with the IBM Statistical Package for Social Sciences (SPSS V19). A one-way Analysis of Variance (ANOVA) was performed in order to determine if aggregated preservation categories were significantly higher than aggregated values for all utilization categories. To elucidate differences between each preservation and utilization dimensions, a two-way ANOVA, with a Tukey's posthoc test was performed.

Significant combinations of landscape categories selected for respondents' preferences for landscapes which they believe should be included in the ideal construct for "nature" and landscapes which should be represented more in their urban area in the future were elucidated through the use of the Pearson's Chi Squared Test. Selections for each landscape category were analyzed to determine the presence of significant variation from a non-weighted category mean (utilizing all possible combination of landscape types), under the assumption that every combination of landscape types was equally likely to be selected. Between group differences were analyzed using the posthoc test where significant differences corresponded to between-group residual value differences being more than two standard error values apart.

Landscape preference categories and nature conservation intent might have been affected by the cultural background of respondents within each study site. As such, landscape preference categories were regressed against respondent demographic information using a stepwise multiple logistic regression. Scores for each dimension under nature conservation intent were regressed against the same demographic variables using a stepwise forward multiple linear regression model. Prior to conducting the regression analysis, the presence of collinearity within the demographic variables were checked by ensuring that Variance Inflation Factors (VIF) of each independent variable was less than 10 (O'Brien, 2007).

Lastly, a stepwise forward multiple linear regressions was performed in order to determine if nature conservation intent significantly affected landscape preference to either tend towards natural or manicured landscapes. This regression was performed using the six dimensions (P1, P2, P3, U1, U2, U3) as independent variables. For this analysis, all landscape categories selected by respondents were aggregated into two dependent variable categories: landscape categories containing natural vegetation (primary and secondary vegetation) and landscape categories that did not contain natural vegetation as part of their selection. All statistics tests were performed at a significance level of $\alpha = 0.05$. Bonferroni's correction was also not used in lieu of the test tending to result in over-conservative outcomes (Perneger, 1998).

2.5 Landscape factor: Land-use analysis at a neighborhood scale

This analysis was conducted to investigate if residents from each study site were potentially exposed to different amounts of natural and manicured landscapes on a daily basis, at a neighborhood scale. Satellite images of Singapore, Tokyo (23 Wards) and Vancouver were obtained from Google Earth (2015) and divided into 0.3 by 0.3 decimal degree grids in Arc Map 10.3 (ESRI). Four grids were then selected randomly and analyzed for area of the following land uses: buildings, private manicured landscape, public manicured landscape, agriculture, naturalistic landscapes and other built areas. Grids areas were normalized using the WGS 1984 coordinate system.

2.5.1 Statistical analysis

Significant percentage difference in the land area of the following landscape categories: buildings, private manicured landscape, public manicured landscape, agriculture, naturalistic landscapes and other built areas, within the four grids in Singapore, Tokyo (23 Wards) and Vancouver were analyzed using the Kruskal Wallis test. The Mann Whitney U-Test was used for posthoc testing. All tests were conducted at a significance level of $\alpha = 0.05$.

2.6 Social/ political supporting factor: Interviews and literature review on current urban biodiversity conservation schemes

Responses to urban biodiversity conservation measures were obtained from open-ended interview sessions with six interviewees working in the field of biodiversity conservation and landscape planning in Singapore. Further interviews were conducted to three individuals working in the same field in Vancouver. Interviews conducted in Singapore took place in August 2011, September 2011 and March 2012 while interviews within Vancouver took place in November 2013 and November 2014. Each interview session lasted approximately 0.5 to one hour. The purpose of the interviews was to complement the relevance of the practical recommendations which were suggested in Chapter 6 of this thesis.

3. RESULTS AND DISCUSSION (ECOLOGICAL FACTOR)

3.1Red-list species-richness by habitat-type (rural-urban gradient)

The habitat occurrence records of red-list species from five biodiversity categories (vascular plants, amphibians, mammals, reptiles and birds) from Singapore, Tokyo (23 Wards) and Vancouver were surveyed across six habitat types along a human modification gradient. Table 4 shows the total number of red-list species which were considered for the species-richness and habitat-type irreplaceability analysis in this review.

Despite having the highest recent extinction rate among conservation-targeted vascular plants, mammals, reptiles, birds and amphibians across all three study sites (615 species), Singapore still harbored the highest red-list species-richness as compared to 967 red-listed species in Tokyo (23 Wards) (with 49 recently extinct species) and 301 red-listed species in Vancouver (1 recently extinct species). The higher level of species-richness in study sites closer to the equator is possibly attributable to the basal difference in biodiversity within tropical, sub-tropical and temperate ecological zones. There are several reasons why tropical regions harbor more biodiversity than their warm and cool temperate counterparts. These reasons point to tropical species having many inter-species overlapping niches, ensuring that high diversity is maintained by higher competition due to niche specificity (so that no single species completely dominates the others) (Molles Jr, 2008). Higher biodiversity in tropical areas can also be attributed to a higher instance of parasitism and mutualism (e.g. epiphytic plants and hemiparasitic mistletoes) in as compared to subtropical and temperate areas (Molles Jr, 2008).

Table 4: Total number and percentage of red-list species considered for species-richness and habitat-type irreplaceability analysis by study site.

Study site	Biodiversity category	Percentage					Total number of conservation-targeted species considered in study
		Total	Declared extinct	Habitats not included in survey	Insufficient information	Remaining (Considered in classification)	
Singapore	Vascular Plants	100.00 (n = 1825)	33.70 (n = 615)	8.55 (n = 156)	3.61 (n = 66)	54.14 (n = 988)	1,116
	Mammals	100.00 (n = 31)	0.00 (n = 0)	9.68 (n = 3)	0.00 (n = 0)	90.32 (n = 28)	
	Reptiles	100.00 (n = 66)	0.00 (n = 0)	24.24 (n = 16)	3.03 (n = 2)	72.73 (n = 48)	
	Birds	100.00 (n = 56)	0.00 (n = 0)	23.21 (n = 13)	0.00 (n = 0)	76.79 (n = 43)	
	Amphibians	100.00 (n = 11)	0.00 (n = 0)	8.16 (n = 2)	12.24 (n = 0)	79.59 (n = 9)	
Tokyo (23 Wards)	Vascular plants	100.00 (n = 1431)	2.24 (n = 32)	18.87 (n = 270)	17.99 (n = 257)	60.90 (n = 872)	967
	Mammals	100.00 (n = 61)	6.56 (n = 4)	34.43 (n = 21)	14.75 (n = 9)	44.26 (n = 27)	
	Reptiles	100.00 (n = 19)	0.00 (n = 0)	36.84 (n = 7)	5.26 (n = 1)	57.90 (n = 11)	
	Birds	100.00 (n = 118)	11.02 (n = 13)	35.59 (n = 42)	12.71 (n = 15)	40.68 (n = 48)	
	Amphibians	100.00 (n = 14)	0.00 (n = 0)	35.71 (n = 5)	0.00 (n = 0)	64.29 (n = 9)	
Vancouver	Vascular plants	100.00 (n = 334)	0.00 (n = 0)	27.85 (n = 93)	0.00 (n = 0)	72.15 (n = 241)	301
	Mammals	100.00 (n = 32)	3.13 (n = 1)	21.89 (n = 7)	0.00 (n = 0)	74.98 (n = 24)	
	Reptiles	100.00 (n = 7)	0.00 (n = 0)	42.86 (n = 3)	0.00 (n = 0)	57.14 (n = 5)	
	Birds	100.00 (n = 42)	0.00 (n = 0)	35.71 (n = 15)	0.00 (n = 0)	64.29 (n = 27)	
	Amphibians	100.00 (n = 5)	0.00 (n = 0)	20.00 (n =1)	0.00 (n = 0)	80.00 (n = 4)	

Regardless of the baseline difference in red-list species-richness, there was a general decrease in species-richness from a rural-urban habitat gradient in all study sties (Figure 7). Gradients of decline however, appear steeper in Singapore, followed by Tokyo (23 Wards) and lastly, Vancouver. This points to the effect of human modification of landscapes being more detrimental to red-list species conservation in tropical, followed by warm-temperate and cool-temperate cities.

This finding is consistent with previous studies on vascular plants and birds conducted in the global North, Israel and Brazil (e.g. Clergeau et al., 1998; Reis et al., 2002; Shwartz et al., 2008; Zerbe et al., 2002). However, this trend was an exception only for conservation-targeted birds in Vancouver where species diversity was found to be relatively consistent across all habitat types, with a slight peak at grassland habitats. This peak could be due to the presence of a higher number of grassland flowering plants as identified through the graph on vascular plant species-richness and supported by findings from the Credit Valley Conservation group (2013). This high plant diversity could have functioned as a food source to support invertebrate diversity, which could then support a high diversity of grassland birds (Credit Valley Conservation group, 2013).

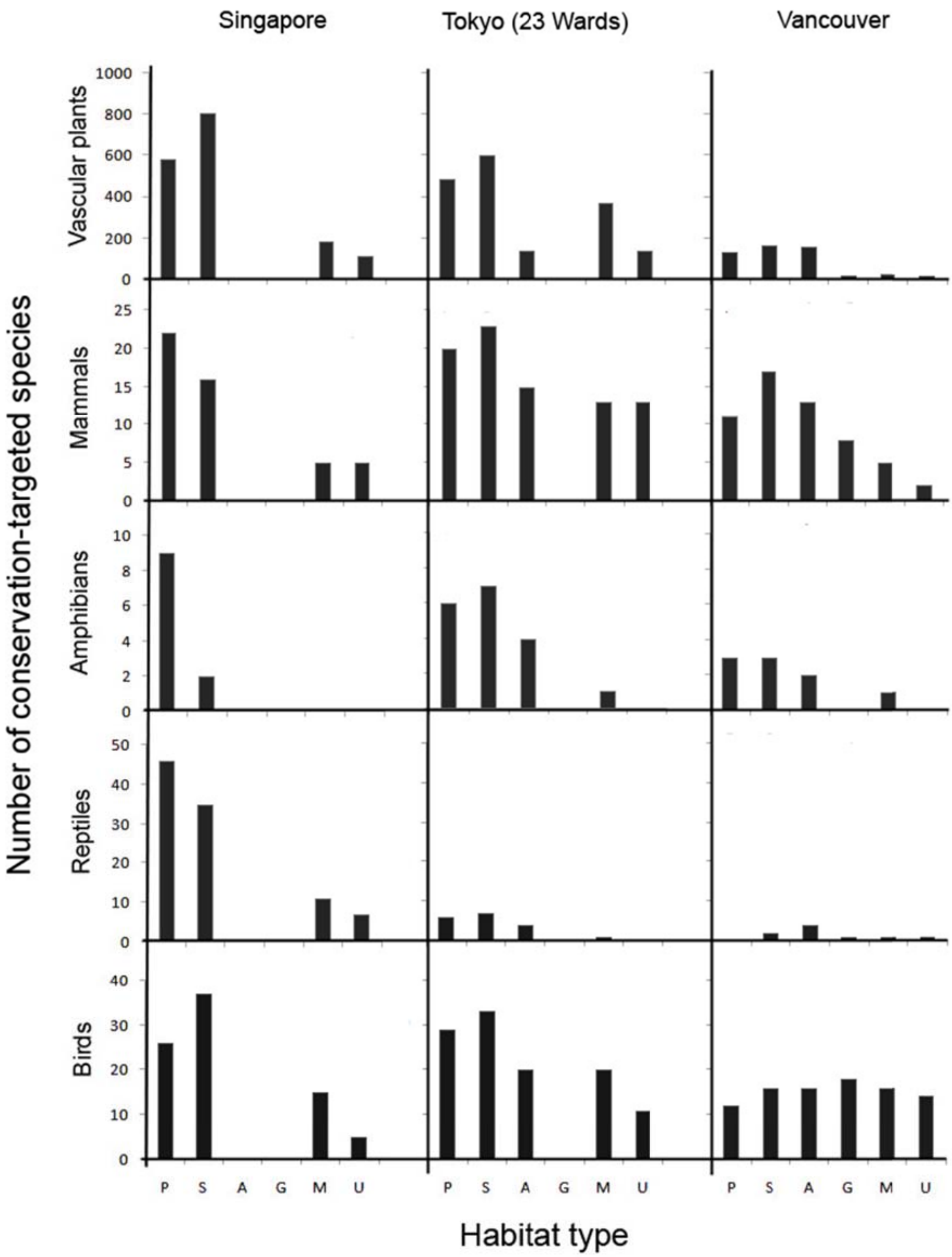


Figure 7: Graph of number of red-list species in six biodiversity categories against landscape type the three study cities. P = primary vegetation, S = secondary vegetation, A = agriculture landscapes (including rice paddies in Tokyo (23 Ward's) case, G = Grassland, M = manicured landscape and U = urban areas.

At first glance, results of species-richness change across habitat types may also point to a distribution pattern consistent with the intermediate disturbance hypothesis commonly found in previous studies in temperate cities and Israel (e.g. Blair and Launer, 1997; Shwartz et al., 2008; Zerbe et al., 2002). Secondary-habitat species-richness peaks were identified for red-listed vascular plant, amphibian and mammal taxas in Vancouver, all biodiversity categories in Tokyo (23 Wards) and vascular plants and birds in Singapore. The secondary-vegetation species-richness peak found in red-listed birds in Singapore might contrast, on the surface, with a similar study in Palmas, Brazil (Reis et al., 2002) where bird species-richness did not exhibit a peak within secondary vegetation. However, the difference may be due in part to the study by Reis et al. (2002) having focused on the diversity of all birds within a given habitat type and not specifically on conservation-targeted birds.

3.1.1 Deviations from the intermediate disturbance hypothesis

In spite of the apparent species-richness peak found in habitats of intermediate disturbance for majority of taxas analyzed in this study, this peak could perhaps be better explained by possible habitat-association with neighboring fragments of primary vegetation. Closer examination of red-list species-richness using species, instead of habitat as an independent grouping factor showed that a large number of species in most investigated taxas were found to inhabit both primary and secondary vegetation instead of being exclusive to either one of the landscape types (Figure 8).

In the case of vascular plants, amphibians and mammals in Vancouver, the proportion of species found in both primary vegetation and secondary vegetation is either greater or equal to the number of species found exclusively in secondary vegetation. This trend was also found for all biodiversity categories in Tokyo (23 Wards) and for vascular plants and birds in Singapore. Accordingly, a large proportion of the biodiversity found in secondary vegetation could have thus been dependent on primary vegetation for essential needs such as food, nesting and breeding grounds (Melles et al., 2003). It is likely that secondary habitats could be a fringe extension of the range of some primary forest dwelling species in the study sites.

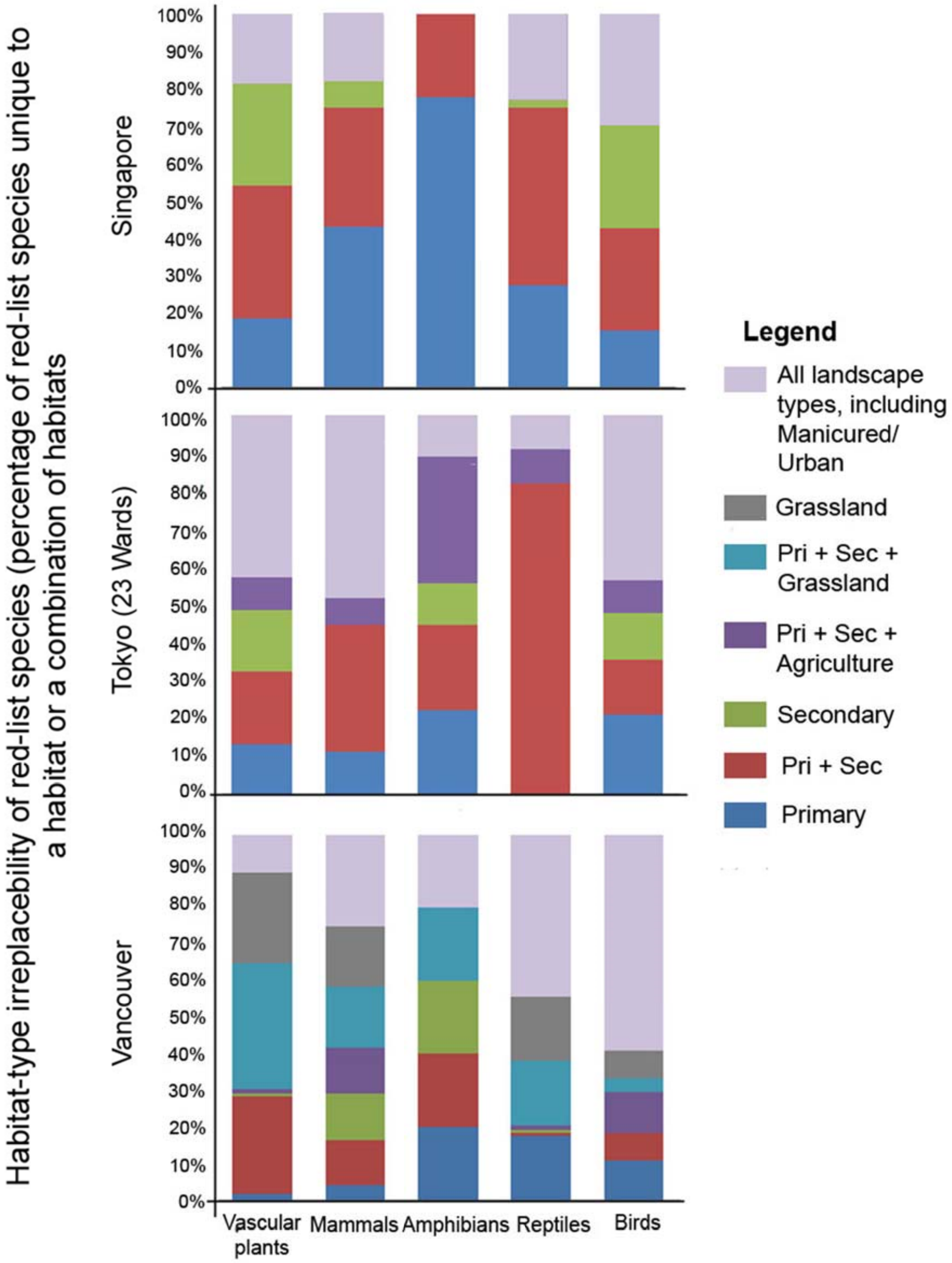


Figure 8: Habitat specific conservation potential (habitat-type irreplaceability) of a landscape or a group of landscapes for five red-list taxas in the three study cities. Data was categorized using species as an independent factor.

3.2 Habitat-type irreplaceability

In this thesis, habitat-type irreplaceability was used as a proxy for conservation-potential. This analysis required the consideration of individual red-list species, instead of habitat types, as an independent grouping factor. Doing so would prevent double counting of any given species, thereby more accurately profiling the conservation-potential as the biological uniqueness of a given habitat type/ group of habitats. Urban areas and manicured landscapes were considered to be a single habitat group in this analysis as both areas can be found in close association. Habitat-type irreplaceability values for urban areas and manicured landscapes for aggregated biodiversity taxa were found to decrease in the order of Vancouver to Tokyo (23 Wards) and Singapore (Table 5). This highlights ecological-zone specific uniqueness in biodiversity conservation potential for each studied city. It also reinforces the result in Section 3.1 which shows that human modification of natural landscapes is more detrimental to red-list species reduction in tropical, followed by warm-temperate and cool-temperate cities.

Table 5: Habitat-type irreplaceability of one, or a combination of habitat types as an average value of the percentage of unique red-list species of vascular plants, mammals, reptiles, birds and amphibians found in each habitat type.

Study site	Habitat-type irreplaceability per habitat/ habitat combination for aggregated taxas						
	Primary	Primary + Secondary	Secondary	Primary + Secondary+ Agriculture	Primary + Secondary + Grassland	Grassland	Urban + Manicured landscapes
Singapore	0.360	0.327	0.125	N/A	N/A	N/A	0.188
Tokyo (23 Wards)	0.135	0.342	0.079	0.134	N/A	N/A	0.310
Vancouver	0.114	0.136	0.029	0.052	0.189	0.138	0.329

In the case of Vancouver, the habitat-type irreplaceability of urban areas and manicured landscapes can potentially be increased from 0.329 to an estimated value of 0.467 when grassland plants, reptiles and birds are considered as potential urban/ manicured landscape vegetation (Benvenuti, 2014; Credit Valley Conservation, 2013). These species have been predicted to adapt easily into urban environments as long as grassland host-plants are used to create a suitable base-habitat that ensures adequate food and shelter prospects (Credit Valley Conservation, 2013). As far as grassland plants are able to create suitable micro-climates for small animals, this benefit does not extend to grassland mammals (e.g. *Bos bison athabascae*). For this reason, grassland mammals were not considered to be urban-adapters as they require large areas of land for sustenance and breeding.

In the context of each study city, decreasing habitat-irreplaceability gaps were found between naturalistic landscapes (primary vegetation) and the urban landscapes in study sites with increasing distance from the equator (Table 5, Figure 9). Tropical naturalistic landscapes (primary vegetation) showed high species uniqueness in lieu of its capability to provide a viable habitat for 696 unique conservation-targeted species over the five investigated taxa. On the other hand, this difference decreases to 210 red-list species in Tokyo (23 Wards) and 173 in Vancouver (Figure 9).

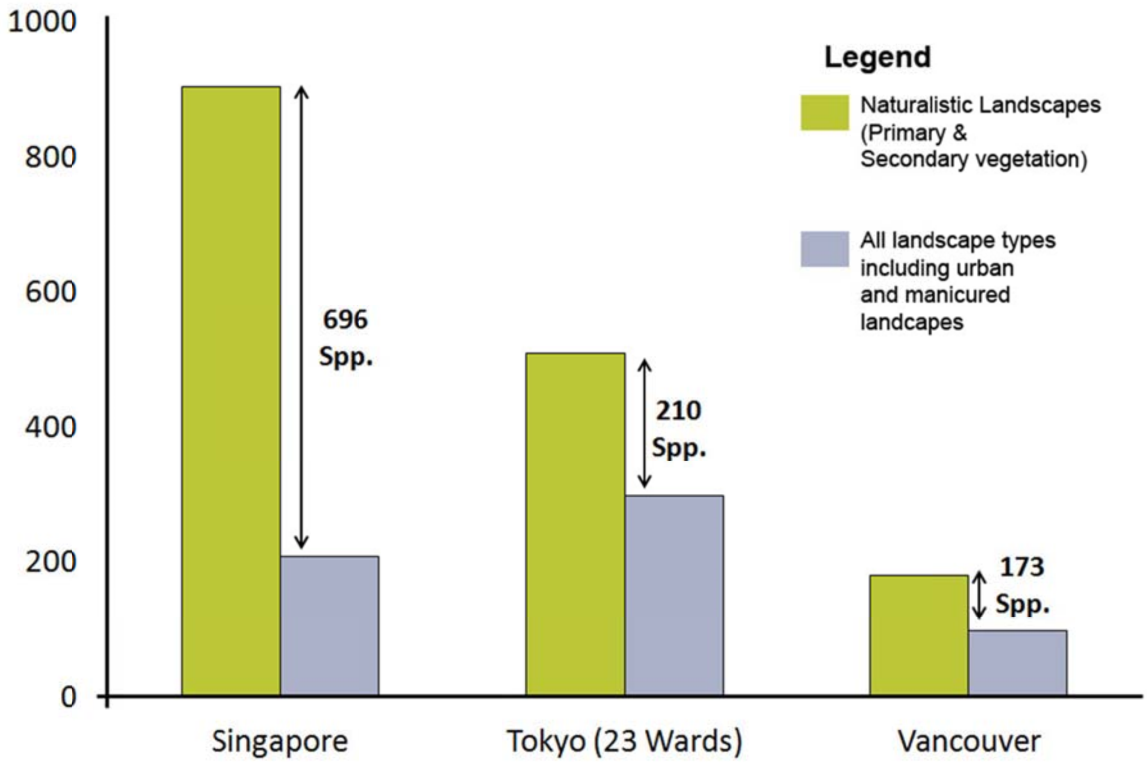


Figure 9: Red-list species richness unique to naturalistic landscapes and urban and manicured landscapes in three study sites. The habitat-type irreplaceability of urban and manicured landscapes in the order of Singapore, Tokyo (23 Wards) and Vancouver is 0.188, 0.310 and 0.329 respectively. The habitat type irreplaceability of a combination of primary, secondary and primary and secondary natural landscapes in the order of Singapore, Tokyo (23 Wards) and Vancouver is 0.812, 0.556 and 0.279 respectively.

Taken into consideration with the earlier-mentioned habitat-type irreplaceability values for urban areas in these three study sites, findings imply that one should be cautious in increasing manicured landscape cover in cities as an across-the-board measure for urban biodiversity conservation. This is because conservation uniqueness of manicured landscapes may be high in cities like Vancouver, but get increasingly lower in cities like Tokyo (23 Wards) and Singapore. In the case of tropical cities such as Singapore, urban and manicured landscapes have the lowest habitat irreplaceablity values as compared to combinations featuring natural habitats (primary and secondary vegetation). Should more area be allocated for green-space increase in tropical cities, consideration should be given to naturalistic design, or increasing connectivity to already-existing natural vegetation. The latter is relevant in light of results that reveal the habitat combination of primary and secondary habitats had the highest habitat-type irreplaceability values in all ecological zones. Close geographical connection to primary remnant forests could again, have a positive feedback on bird and plant diversities within habitats of intermediate human disturbance due to the wider availability of food and habitat resources (Melles et al., 2003; Hodgkison et al., 2007).

3.2.1 Black clouds and silver linings: Urban areas and manicured landscapes for biodiversity conservation

The ecological results presented in section 3.1 and section 3.2 have shown so far that natural landscapes (primary and secondary landscapes) still support the highest number of species especially in tropical and warm temperate cities. However this does not mean that manicured landscapes and urban areas should be deemed as “hopeless” for urban biodiversity conservation. This study has shown that, in the case of cold temperate areas like Vancouver, urban areas and manicured landscapes have even higher habitat-type irreplaceability than natural landscapes. It is also optimistic to know that urban areas across all ecological zones can harbor a habitat-type irreplaceability value of at least 0.188. This corresponds to at least 100 red-list species irrespective of ecological zone (Figure 6). Implications for this may point to an even higher actual diversity present in urban areas as red-list species are indicators for wider biodiversity.

Results of this study are validated by previous, recent studies on urban areas having a substantial potential to conserve urban biodiversity. Much of these researches have been conducted in cool temperate or temperate regions. As mentioned briefly in the introduction section (1.2), work done by Cornelis & Hermy (2004) show that urban and suburban manicured parks in Flanders, Belgium can potentially harbor up to 60% of vascular plants, birds, butterflies and amphibians. Vascular plant species richness within urban areas was discovered to be even higher than surrounding human-modified forests in Guangzhou, China, Berlin, Germany and Christchurch, New Zealand (Kühn et al., 2004; Stewart et al., 2004; Zheng, 1995).

With regards to other studies detailing the conservation potential of urban areas in terms of red-list species richness, Colding et al. (2003) have discovered that urban Stockholm is able to harbor about 66% of the red-list Swedish species. This is similar to the habitat-type irreplaceability value of 0.467 in Vancouver's city center, should red-list grassland plants, birds and reptiles be successfully integrated into the urban environment. It could also be postulated that urban populations are required in order to sustain biodiversity. This is especially pertinent to cities such as Tokyo (23 Wards) which harbor the highest red-list species richness in comparison to the other two study sites.

There have been numerous studies on the positive effect that human modification has on red-list species richness in cities. Araújo (2003) and Balmford et al., (2001) conducted studies across sub-Saharan Africa (warm and cool temperate regions) and discovered a positive correlation between level of human modification in landscapes and general, and red-list species diversity. Similar to the case in Tokyo (23 Wards) described in this study, causes for this correlation could be due to the introduction of exotic species and increased niche provision in urban areas (Araújo, 2003). As much as exotic species could turn invasive and displace native species, the converse case where non-invasive exotic species could function as a diversified food source for existing native species. An example of this is the red-listed species *Dendrelaphis kopsteini* (Kopstein's bronzeback snake) predating on the invasive changeable lizard (*Calotes versicolor*) in Singapore (McCleary & Ichtiarani, 2005). Furthermore manicured landscapes within urban areas may provide protection for native biodiversity, especially birds, in lieu of the fact that these landscapes are too small for the establishment of large predators and carriers of parasites (Garden et al., 2006).This shows a promising prospect of utilizing urban environments for conservation.

However, further study is needed on the autecology of urban-adapted red-list species. This is to ascertain if these species have developed long-standing physiological or/ and behavioral adaptations to urban environments. A case of behavioral adaptation could be seen in the red-listed large Indian civet (*Viverra zibetha*) in Singapore where there is evidence of generational behavior adapted to scavenging food in urban areas (sometimes stealing from house kitchens) (Chua et al. 2012). However, a case where red-list species could have coincidentally occurred in urban areas could be black bearded tomb bats (*Taphozous melanopogon*) utilizing building faces and walls for roosting. However, is unclear if this is a behavioral adaption (like the Large Indian Civet) or if these species just happened to find suitable habitats after displacement from natural areas. Garden et al. (2006) has also found that small areas of manicured landscapes may in fact, serve to promote urban bird species-richness in urban areas in Australia due to the resultant patch not being able to support natural predators and parasites.

3.3 Summary

This chapter aims to put forward the main point that Singapore, Tokyo (23 Wards) and Vancouver are ecologically unique with respect to the total number of red-list species and habitat-specific red-list species richness.

A) Section 3.1: Red-list species richness across a rural-urban gradient has been found to decline across all study sites. However the steeper gradient of decrease in the order of Singapore, Tokyo (23 Wards) and Vancouver, show that human modification of natural landscapes is more detrimental to red-list species reduction in tropical, followed by warm-temperate and cool-temperate cities.

B) Section 3.2: Habitat-type irreplaceability values show that naturalistic landscapes (primary and secondary vegetation) have a higher conservation potential in the order of Singapore, Tokyo (23 Wards) and Vancouver. Conversely, the conservation potential of urban and manicured landscapes is highest in the reverse order.

C) Section 3.1 & 3.2: Taking A) and B) into consideration, red-list species conservation is easier in natural landscapes by ecological-default in the order of Singapore, Tokyo (23 Wards) and Vancouver.

D) Section 3.2.1: Despite C), urban areas should not be overlooked in terms of their conservation potential as they are able to at least 100 red-list species irrespective of ecological zone (Figure 9). Implications for this may point to an even higher actual diversity present in urban areas as red-list species are indicators for a wider amount biodiversity. Human intervention may actually be good for promoting biodiversity in cities. This is especially in cities where urban areas provide increased food sources for urban species and nesting habitats (e.g. Chua et al. 2012) or have a level of habitat modification which prevents the establishment of predators and parasites (Garden et al., 2006).

4. RESULTS AND DISCUSSION (SOCIAL FACTOR)

4.1 Landscape perception

Questionnaires were conducted with urban residents in Singapore, Tokyo (23 Wards) and Vancouver in order to understand how the factors of nature conservation intent interacted with scenic aesthetic landscape preference [as mentioned in Section 1.4.2 (academic gap in the social aspect of measuring urban biodiversity conservation) and section 1.5 (research purpose)]. Scenic aesthetics within a landscape is in turn, connected with varying degrees of visual human modification and hence, biodiversity conservation potential.

Response rates were 30% (90 / 300) in Singapore, 16% in Tokyo (23 Wards) (313 / 2000) and 11% in Vancouver (110 / 1000). Male and female respondents were roughly equal in all three cities with the former making up 52.3% (Singapore), 46.3% (Tokyo, 23 Wards) and 46.8% (Vancouver) of the total sample. In all cities, questionnaire respondents were citizens of their respective countries with the exception of two responses in Singapore (which were excluded in the analysis, bringing the final response rate to 29%). In all cases, sample sizes obtained were higher than the minimum sample size of 85 required (see section 2.4.1.).

4.1.1 Collinearity between demographic factors

Variance Inflation Factor scores for collinearity analysis between demographic factors in Singapore, Tokyo (23 Wards) and Vancouver were all less than a value of 10(Tables 6, 7, 8). As such, the subsequent ANOVA, logistic and multiple linear regression analyses could be performed with the assurance that inter-relationships between demographic factors would not function as confounding elements.

Table 6: Collinearity analysis between demographic factors in the Singapore dataset.

Demographic factors and associated VIF (Tolerance) values						
	Age	Sex	Occupation	Overseas residence for > 2 years	Ecology/ Conservation class	Summed exposure
Age	N/A	1.10 (0.91)	1.61 (0.62)	1.31 (0.76)	1.29 (0.78)	1.10 (0.91)
Sex	2.07 (0.48)	N/A	1.85 (0.54)	1.30 (0.78)	1.77 (0.85)	1.22 (0.82)
Occupation	1.21 (0.83)	1.10 (0.92)	N/A	1.06(0.95)	1.24(0.81)	1.15(0.87)
Overseas residenceor> 2 years	2.00 (0.50)	1.09 (0.92)	1.76 (0.57)	N/A	1.24(0.80)	1.18(0.85)
Ecology/ conservation class	1.95 (0.51)	1.01 (0.99)	1.77 (0.57)	1.07 (0.94)	N/A	1.19 (0.84)
Summed exposure	1.85 (0.54)	1.09 (0.92)	1.68 (0.60)	1.04 (0.96)	1.22(0.82)	N/A

Table 7: Collinearity analysis between demographic factors in the Tokyo (23 Wards) dataset.

	Demographic factors and associated VIF (Tolerance) Values										
	Sex	Age	Occupation	Residence in Japan but outside 23 Wards for > 2 years	Overseas residence for >2 years	Ecology/ Conservation classes	Environmental/ nature NGO experience	Exposure 1 (Gardens)	Exposure 2 (Zoos)	Exposure 3 (Nature Reserves)	Exposure 4 (Rural areas)
Sex	N/A	1.40(0.72)	1.31(0.76)	1.03(0.98)	1.04(0.96)	1.18(0.85)	1.09(0.92)	1.09(0.92)	1.20(0.84)	1.23(0.82)	1.25(0.80)
Age	1.12(0.90)	N/A	1.07(0.94)	1.03(0.98)	1.04(0.96)	1.15(0.87)	1.09(0.92)	1.09(0.92)	1.20(0.84)	1.22(0.82)	1.24(0.81)
Occupation	1.11(0.91)	1.13(0.89)	N/A	1.03(0.98)	1.04(0.96)	1.19(0.84)	1.08(0.92)	1.09(0.92)	1.22(0.82)	1.24(0.81)	1.23(0.81)
Residence in Japan but outside 23 Wards for > 2 years	1.23(0.82)	1.54(0.65)	1.45(0.69)	N/A	1.04(0.96)	1.19(0.84)	1.09(0.92)	1.09(0.92)	1.23(0.82)	1.23(0.82)	1.25(0.80)
Overseas residence for >2 years	1.23(0.82)	1.53(0.65)	1.46(0.69)	1.03(0.98)	N/A	1.18(0.85)	1.10(0.92)	1.10(0.92)	1.22(0.82)	1.24(0.81)	1.25(0.80)
Ecology/ Conservation classes	1.22(0.82)	1.49(0.67)	1.46(0.69)	1.03(0.98)	1.03(0.97)	N/A	1.05(0.95)	1.09(0.92)	1.23(0.82)	1.23(0.82)	1.23(0.82)
Environmental/ nature NGO experience	1.22(0.82)	1.53(0.66)	1.44(0.70)	1.02(0.98)	1.04(0.96)	1.14(0.88)	N/A	1.09(0.92)	1.22(0.82)	1.23(0.81)	1.25(0.80)
Exposure 1 (Gardens)	1.22(0.82)	1.53(0.65)	1.45(0.69)	1.03(0.97)	1.04(0.96)	1.19(0.84)	1.10(0.91)	N/A	1.18(0.85)	1.22(0.82)	1.25(0.80)
Exposure 2 (Zoos)	1.20(0.83)	1.50(0.67)	1.45(0.69)	1.03(0.97)	1.04(0.96)	1.19(0.84)	1.09(0.92)	1.05(0.95)	N/A	1.21(0.83)	1.23(0.82)
Exposure 3 (Nature Reserves)	1.22(0.82)	1.52(0.66)	1.46(0.69)	1.02(0.98)	1.04(0.96)	1.18(0.85)	1.09(0.92)	1.08(0.92)	1.20(0.84)	N/A	1.15(0.87)
Exposure 4 (Rural areas)	1.23(0.82)	1.51(0.66)	1.43(0.70)	1.02(0.98)	1.04(0.96)	1.16(0.86)	1.10(0.91)	1.09(0.92)	1.20(0.84)	1.13(0.88)	N/A

Table 8: Collinearity analysis between demographic factors in the Vancouver dataset.

	Demographic factors and associated VIF (Tolerance) Values										
	Sex	Age	Occupation	Residence in Canada but outside Vancouver > 2 years	Overseas residence for >2 years	Ecology/ Conservation classes	Environmental/ nature NGO experience	Exposure 1 (Gardens)	Exposure 2 (Zoos)	Exposure 3 (Nature Reserves)	Exposure 4 (Rural areas)
Sex	N/A	1.45(0.69)	1.43(0.70)	1.11(0.90)	1.06(0.94)	1.13(0.89)	1.07(0.94)	1.16(0.87)	1.29(0.77)	1.26(0.79)	1.38(0.73)
Age	1.14(0.87)	N/A	1.07(0.93)	1.11(0.90)	1.05(0.95)	1.09(0.92)	1.11(0.90)	1.17(0.86)	1.30(0.77)	1.28(0.78)	1.38(0.73)
Occupation	1.17(0.85)	1.12(0.90)	N/A	1.11(0.90)	1.06(0.94)	1.07(0.93)	1.10(0.91)	1.17(0.86)	1.31(0.77)	1.29(0.78)	1.38(0.72)
Residence in Canada but outside Vancouver > 2 years	1.16(0.86)	1.48(0.68)	1.43(0.70)	N/A	1.06(0.95)	1.13(0.89)	1.16(0.90)	1.12(0.89)	1.29(0.77)	1.29(0.78)	1.33(0.75)
Overseas residence for >2 years	1.17(0.85)	1.47(0.68)	1.43(0.70)	1.11(0.90)	N/A	1.13(0.88)	1.12(0.90)	1.15(0.87)	1.31(0.77)	1.31(0.77)	1.38(0.73)
Ecology/ Conservation classes	1.17(0.85)	1.43(0.70)	1.36(0.74)	1.12(0.90)	1.06(0.94)	N/A	1.11(0.90)	1.16(0.86)	1.29(0.78)	1.31(0.77)	1.38(0.72)
Environmental/ nature NGO experience	1.12(0.90)	1.49(0.67)	1.42(0.71)	1.12(0.90)	1.06(0.94)	1.12(0.89)	N/A	1.16(0.86)	1.31(0.76)	1.31(0.76)	1.38(0.73)
Exposure 1 (Gardens)	1.16(0.86)	1.49(0.67)	1.43(0.70)	1.07(0.93)	1.04(0.96)	1.13(0.89)	1.10(0.90)	N/A	1.31(0.77)	1.28(0.78)	1.36(0.74)
Exposure 2 (Zoos)	1.16(0.86)	1.49(0.68)	1.43(0.70)	1.11(0.91)	1.06(0.94)	1.11(0.90)	1.12(0.90)	1.17(0.86)	N/A	1.23(0.81)	1.26(0.80)
Exposure 3 (Nature Reserves)	1.13(0.89)	1.46(0.69)	1.41(0.71)	1.10(0.91)	1.06(0.94)	1.13(0.89)	1.12(0.90)	1.14(0.88)	1.23(0.81)	N/A	1.34(0.75)
Exposure 4 (Rural areas)	1.17(0.86)	1.48(0.68)	1.43(0.70)	1.07(0.93)	1.06(0.94)	1.13(0.89)	1.11(0.90)	1.15(0.87)	1.19(0.84)	1.27(0.79)	N/A

4.1.2 Nature conservation intent (Landscape level)

Nature conservation intent at a landscape level was measured using six first-order attitudinal scales. These six scales quantify respondents' relation to natural landscapes and their biotic components through the dimensions of experience (P1), pro-conservation action (P2), emotional connection (P3), pro-conservation action motivated by human benefit (U1), degree of connectedness with nature (U2) and the willingness to utilize/ alter nature for human gain (U3). In turn, the six scales are collapsible into a two-dimensional second-order factor quantifying preservation or utilization of natural landscapes and their associated biotic components.

Results reveal that, urban-dwellers in Singapore, Tokyo (23 Wards) and Vancouver significantly value the preservation of natural landscape and its biotic components over its utilization. Aggregated scores for all preservation (P1, P2, P3) and utilization dimensions (U1, U2, U3) were consistently higher for the former in all three cities, regardless of location (Table 9).

Table 9: Aggregated score for preservation and utilization dimensions in Singapore, Tokyo (23 Wards) and Vancouver. All aggregated preservation scores were significantly higher than aggregated utilization scores at $\alpha = 0.05$.

City	**Mean ± SE**		**df_1**	**df_2**	**ANOVA p value**
	Preservation aggregate score (P1, P2, P3)	**Utilization aggregate score (U1, U2, U3)**			
Singapore	3.89 ± 0.07	3.09 ± 0.14	2	3060	< 0.001
Tokyo (23 Wards)	3.76 ± 0.17	3.10 ± 0.19	1	6884	< 0.001
Vancouver	4.10 ± 0.064	2.56 ± 0.060	1	217	< 0.001

The unanimous tendency for respondents in all three cities to hold the intent for the preservation of natural landscapes (and their associated biotic components) is consistent with heightened ecological awareness throughout the globe (Schultz, 2000). This positive trend can be attributed to a range of direct and indirect causes such as increased accessibility to environmental education, pro-environmental advertising, and the rising popularity of urban movements involve interaction with nature (e.g. urban agriculture) (Schultz, 2000; Mendes et al., 2008; Choo, 2011).Since the turn of the 21st century, higher education institutes in Singapore, Tokyo (23 Wards) and Vancouver have started to promote programs dedicated to environmental sustainability (e.g. Center for Sustainable Asian Cities at the National University of Singapore, the Institute for Resources, Environment and Sustainability at the University of British Columbia and the Graduate Program in Sustainable Science at the University of Tokyo). Likewise, companies such as the Edible Garden City (Singapore), Omotesando rooftop farm [Tokyo (23 Wards)] and City Farmer (Vancouver), among others, have also emerged to promote environmentally friendly urban farming as viable sub-cultures.

Despite the emergence of a clear preservation intent among the urban-dwellers in all three cities, the difference between aggregate preservation and utilization scores were most pronounced in Vancouver, followed by Singapore, then Tokyo (23 Wards). Results suggesting that Singaporeans and Vancouverites may have a more pronounced valuation of natural landscape conservation are supported by analysis of the scores attributed to individual dimensions used to quantify preservation and utilization of nature at a landscape level.

In Singapore and Vancouver, all three dimensions corresponding to natural landscape preservation (P1, P2 and P3) had significantly higher scores as compared to dimensions corresponding to natural landscape utilization (U1, U2 and U3). However, the response gathered from Tokyo (23 Wards) was less straightforward, with two preservation dimensions (P1 and P2) overlapping with a dimension corresponding to utilization (U1).Figure 10 and Table 10 detail the score differences between the six dimensions along with between-group significance values (2-way ANOVA).

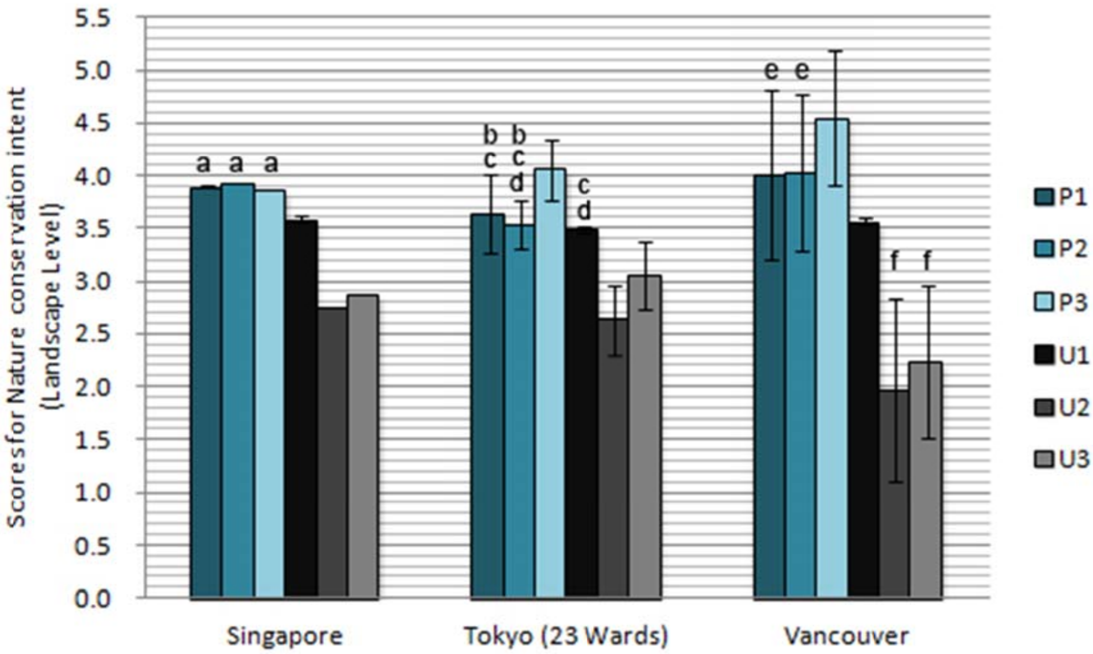


Figure 10: Mean and standard error values of the six categories corresponding to different dimensions of preservation and utilization of natural landscape (and its associated biotic components) in Singapore, Tokyo (23 Wards) and Vancouver. The letters above the graph show categories that are not significantly different from each other (2 way ANOVA). Exact p-values and 95% confidence intervals can be found in Table 10.

Note: P1: Experiential enjoyment of natural landscapes, P2: Pro-conservation behavior; P3: Emotional concern; U1: Pro-conservation behavior motivated by human benefit, U2: Disconnect with nature, U3: Utilizing/ altering natural landscapes for human benefit.

Table 10: Scores for the six categories quantifying attitudes for preservation and utilization of natural landscapes in Singapore, Tokyo (23 Wards) and Vancouver

City	Perception category (I)	(J)	Mean difference (I – J)	2 way ANOVA p value	95% Confidence interval Lower bound	Upper bound
Singapore	(P1) Experiential enjoyment of natural landscapes	P2	- 0.030	0.619	- 0.15	0.09
		P3	0.03	0.597	- 0.09	0.15
		U1	0.31	< 0.001	0.19	0.43
		U2	1.11	< 0.001	0.99	1.24
		U3	1.01	< 0.001	0.89	1.13
	(P2) Pro-conservation behavior	P1	0.03	0.619	-0.09	0.15
		P3	0.06	0.305	-0.06	0.18
		U1	0.34	< 0.001	0.22	0.46
		U2	1.15	< 0.001	1.02	1.27
		U3	1.04	< 0.001	0.92	1.16
	(P3) Emotional concern	P1	-0.03	0.597	-0.015	0.09
		P2	-0.06	0.305	-0.018	0.06
		U1	0.28	< 0.001	0.16	0.40
		U2	1.08	< 0.001	0.96	1.21
		U3	0.98	< 0.001	0.86	1.10
	(U1) Pro-conservation behavior (for human benefit)	P1	-0.31	< 0.001	-0.43	-0.19
		P2	-0.34	< 0.001	-0.46	-0.22
		P3	-0.28	< 0.001	-0.40	-0.16
		U2	0.80	< 0.001	0.68	0.93
		U3	070	< 0.001	0.58	0.82
	(U2) Disconnect with nature	P1	-1.11	< 0.001	-1.24	-0.99
		P2	-1.15	< 0.001	-1.27	-1.02
		P3	-1.08	< 0.001	-1.21	-0.96
		U1	-0.80	< 0.001	-0.93	-0.68
		U3	-0.10	< 0.001	-0.23	0.02
	(U3) Altering natural landscapes for human benefit	P1	-1.01	< 0.001	-1.13	-0.89
		P2	-1.03	< 0.001	-1.16	-0.92
		P3	-0.98	< 0.001	-1.10	-0.86
		U1	-0.70	< 0.001	-0.82	-0.58
		U2	0.10	< 0.001	-0.02	0.23

	(P1) Experiential enjoyment of natural landscapes	P2	0.100	0.218	- 0.15	0.09
		P3	-0.411	< 0.001	- 0.09	0.15
		U1	0.136	0.003	0.19	0.43
		U2	1.001	< 0.001	0.99	1.24
		U3	0.595	< 0.001	0.89	1.13
	(P2) Pro-conservation behavior	P1	-0.100	0.218	-0.09	0.15
		P3	-0.510	< 0.001	-0.06	0.18
		U1	0.063	0.641	0.22	0.46
		U2	0.901	< 0.001	1.02	1.27
		U3	0.495	< 0.001	0.92	1.16
	(P3) Emotional concern	P1	0.411	< 0.001	-0.015	0.09
		P2	0.510	< 0.001	-0.018	0.06
		U1	0.573	< 0.001	0.16	0.40
		U2	1.412	< 0.001	0.96	1.21
		U3	1.006	< 0.001	0.86	1.10
Tokyo (23 Wards)	(U1) Pro-conservation behavior (for human benefit)	P1	-0.163	0.003	-0.43	-0.19
		P2	-0.036	0.641	-0.46	-0.22
		P3	-0.573	< 0.001	-0.40	-0.16
		U2	0.838	< 0.001	0.68	0.93
		U3	0.432	< 0.001	0.58	0.82
	(U2) Disconnect with nature	P1	-1.001	< 0.001	-1.24	-0.99
		P2	-0.901	< 0.001	-1.27	-1.02
		P3	-1.412	< 0.001	-1.21	-0.96
		U1	-0.838	< 0.001	-0.93	-0.68
		U3	-0.406	< 0.001	-0.23	0.02
	(U3) Altering natural landscapes for human benefit	P1	-0.595	< 0.001	-1.13	-0.89
		P2	-0.495	< 0.001	-1.16	-0.92
		P3	-1.006	< 0.001	-1.10	-0.86
		U1	-0.432	< 0.001	-0.82	-0.58
		U2	0.406	< 0.001	-0.02	0.23

	(P1) Experiential enjoyment of natural landscapes	P2	-0.018	1.000	-0.33	0.29
		P3	-0.541	< 0.001	-0.85	-0.23
		U1	0.450	< 0.001	0.14	0.76
		U2	2.037	< 0.001	1.73	2.34
		U3	1.768	< 0.001	1.46	2.08
	(P2) Pro-conservation behavior	P1	0.018	1.000	-0.29	0.33
		P3	-0.523	< 0.001	-0.83	-0.22
		U1	0.468	< 0.001	0.16	0.77
		U2	2.055	< 0.001	1.75	2.36
		U3	1.787	< 0.001	1.48	2.09
	(P3) Emotional concern	P1	0.541	< 0.001	0.23	0.85
		P2	0.523	< 0.001	0.22	0.83
		U1	0.991	< 0.001	0.68	1.30
		U2	2.578	< 0.001	2.27	2.88
		U3	2.310	< 0.001	2.00	2.62
Vancouver	(U1) Pro-conservation behavior (for human benefit)	P1	-0.450	< 0.001	-0.76	-0.14
		P2	-0.468	< 0.001	-0.77	-0.16
		P3	-0.991	< 0.001	-1.30	-0.68
		U2	1.587	< 0.001	1.28	1.89
		U3	1.319	< 0.001	1.01	1.63
	(U2) Disconnect with nature	P1	-2.037	< 0.001	-2.34	-1.73
		P2	-2.055	< 0.001	-2.36	-1.75
		P3	-2.578	< 0.001	-2.88	-2.27
		U1	-1.587	< 0.001	-1.89	-1.28
		U3	-0.268	0.128	-0.58	0.04
	(U3) Altering natural landscapes for human benefit	P1	-1.768	< 0.001	-2.08	-1.46
		P2	-1.787	< 0.001	-2.09	-1.48
		P3	-2.310	< 0.001	-2.62	-2.00
		U1	-1.319	< 0.001	-1.63	-1.01
		U2	0.268	0.128	-0.04	0.58

It has been recognized that many factors, ranging from monetary and time constraints to religion make up an individual's attitude towards natural areas (e.g. Kaiser & Shimoda, 1999; Dietz et al., 2002; Bamberg & Moser, 2007). Within these, two factors stand out as having a relatively consistent track record for being positively correlated to pro-environmental and pro-conservation behavior. One of these factors is the degree of connectedness humans feel with the natural environment (e.g. Schultz, 2000; Clayton, 2003; Frantz et al., 2005; Fischer & Young, 2007; Schroeder, 2007; Brun i& Schultz, 2010). This trend is also evident from the inter-dimensional analysis which point to a unanimous ranking of the U2 - disconnect with nature as the lowest ranking dimension in all three cities.

The other factor which is relatively constant in its positive correlation with pro-conservation behavior is the place-attachment to natural areas (e.g. Vaske & Korbin, 2001; Kyle et al., 2004). Studies by Cass and Walker (2009) and Wakefield et al. (2001), for example, explain that place-attachment can result in the exhibition of place-protective behavior, especially when the location is under threat. It is thus, interesting to note that for the population which frequent naturalistic areas such as nature reserves the least often [21.5% of survey respondents in the Singapore dataset, compared with 51.8% in the Tokyo (23 Wards) dataset and 57.8% in the Vancouver dataset] ranked all three preservation dimensions in the same highest rank.

Therefore, there may be evidence pointing towards the intent to conserve nature remaining at the "mental construct" level in Singapore. Residents could lack the practical understanding and appreciation of natural landscapes which can only be provided by experience in said landscapes. This condition could foreshadow results of the landscape preference portion of the questionnaire (Sections 4.1.3 and 4.1.4) where nature conservation intent was not consistently reflected to landscapes with the highest habitat-type irreplaceability values.

4.1.3 Landscapes perceived as "Nature"

The first of the two questions aiming to quantify respondents' landscape preference targeted the landscape categories that respondents believed should be included in their ideal conception of "nature". In terms of frequency, primary vegetation was the term coming up most often in respondents' definition of nature in Singapore (38%) and Vancouver (25%), followed by secondary vegetation, and with manicured landscapes and urban areas being the second least and least nature-associated areas. Tokyoites exhibited a differing trend where manicured landscapes were selected most frequently (14%), followed by secondary landscapes (19%) and urban areas (18%).

This trend was echoed in the selection of preferred landscapes by categories. Table 11 details the results of the preference analysis in all three study cities. Urban landscapes do not feature at all in the top three combinations of landscape categories in Vancouver and only feature once within the third rank in Singapore. However, the opposite was found for the Tokyo (23 Wards) dataset, where landscapes with high human influence featured in all top three combinations. Furthermore, there was more variance within the landscape ranks in Tokyo (23 Wards) as compared to Singapore and Vancouver.

Table 11: Top three significant landscape categories which respondents believe should be included in the term "Nature" in Singapore, Tokyo (23 Wards) and Vancouver.

City	Landscape categories	Percentage	Standardized Residual *[(O-E/) √E]*	Rank
Singapore *Note: Categories shown tested to be significantly different with the Pearson's Chi-squared Goodness of fit test (p<0.05, positive values for [(O-E/) √E] > 2SE (1.00))*	Primary vegetation + Secondary vegetation + Manicured landscape	47.00	5.67	1
	Primary vegetation + Secondary vegetation	28.00	4.72	2
	Primary vegetation	0.10	2.67	3
	Primary vegetation + Secondary vegetation + Manicured landscape +Urban Areas	0.10	1.03	3
Tokyo (23 Wards) *Note: Categories shown tested to be significantly different with the Pearson's Chi-squared Goodness of fit test (p<0.05, positive values for [(O-E/) √E] > 2SE (1.14))*	Urban areas + Manicured landscape	9.90	8.58	1
	Manicured landscape	8.95	7.49	1
	Secondary vegetation + Manicured landscape	8.63	7.12	1
	Urban farms + Manicured landscape + Urban areas	6.71	4.93	2
	Primary vegetation	5.43	3.47	3
	Urban areas	5.43	3.47	3
	Primary vegetation + Secondary vegetation + Rice paddy + Urban farms + Manicured landscape + Urban areas	5.11	3.10	3
Vancouver *Categories shown are tested to be significantly different with the Pearson's Chi-squared Goodness of fit test (p<0.05, positive values for [(O-E/) √E] > 2SE (1.06))*	Primary vegetation +Secondary vegetation+ Grassland + Agriculture land + Manicured landscape	26.60	24.3	1
	Primary vegetation+ Secondary vegetation+ Grassland	11.01	7.30	2
	Primary vegetation + Secondary vegetation + Grassland + Agriculture land	10.01	6.30	2/3
	Primary vegetation + Secondary vegetation	9.17	5.30	3

This selection is interesting, especially in light of questionnaire results (nature conservation intent, section 4.1.2) showing that respondents view themselves as being connected with nature (evident from the category of U2 - Humanistic perception, having significantly lowest scores in all study cities). Along these lines, it is expected that urban environments would be included as being part of respondents' definition of nature. This however, was only the case in responses received from Tokyo (23 Wards).

Having urban environments excluded by the majority of the questionnaire respondents in Singapore and Vancouver could point to the possibility that respondents believe that humans are part of nature insofar as this does not extend to landscapes with high visible levels of human disturbance/ modification. This is evidenced from the inclusion of manicured landscapes within the top three choices of landscapes constituting "nature" in Singapore and Vancouver. This could also suggest that respondents from Singapore and Vancouver believe that humans are part of nature only at a conceptual level, which did not extend to the visual-based grouping of pictures with high levels of human impact in the same category with pictures which have clearly more biotic components.

This is further supported by respondents' reasons for selecting a certain landscape type as being part of their definition of nature in Tokyo (23 Wards) and Vancouver. More often than not, the consistent top reason given by Tokyoites is that selected landscapes are "nature" within the city's context as they are familiar scenery (i.e. already present in the built environment). In Vancouver, answers were more nature-centric and pro-biodiversity. Landscapes are seen as "nature" if they provide habitats for both humans and other species as well.

Table 12: Summary of the top three themes in qualitative responses to landscapes that respondents believe should be included as "nature" in Tokyo (23 Wards) and Vancouver.

Landscape type	Tokyo (23 Wards)	Vancouver
Urban areas (Tokyo, 23 Wards: n = 72) (Vancouver: n = 6)	1. Existing/ familiar scenery (n = 28, 39%) 2. Humans as part of nature/ obvious evidence of human modification (n = 26, 36%) 3. Contains biodiversity/ greenery (n = 15, 21%)	1. Existing/ familiar scenery (n = 3, 50%) 2. Humans as part of nature/ obvious evidence of human modification (n = 2, 33%) 3. Contains biodiversity/ greenery (n = 1, 17%)
Manicured landscapes (Tokyo, 23 Wards: n = 115) (Vancouver: n = 38)	1. Existing/ familiar scenery (n = 41, 36%) 2. Balance of human and natural features (n = 31, 27%) 3. Humans as part of nature/ obvious evidence of human modification (n = 20, 17%)	1. Provides spiritual/ recreational ecosystem service (n = 11, 29%) 2. Nature in the absence of pristine landscapes (n = 9, 24%) 3. Existing/ familiar scenery (n = 8, 21%)
Urban agriculture (Tokyo, 23 Wards: n = 73) (Vancouver: n = 31)	1. Existing/ familiar scenery (n = 55, 75%) 2. Provides spiritual/ recreational ecosystem service (n = 7, 10%) 3. Past landscape of Tokyo (n = 6, 8%)	1. Provides ecosystem services – food provision (n = 11, 37%) 2. Contains biodiversity (n = 7, 23%) 3. Nature in the absence of pristine landscape (n = 6, 20%)
Rice/ paddy fields (Tokyo, 23 Wards: n = 10)	1. Existing/ familiar scenery (n = 4, 40%) 2. Contains biodiversity/ greenery (n = 3, 30%) 3. Past landscape of Tokyo (n = 2, 20%)	N/A

Grasslands (Vancouver: n = 43)	N/A	1. Original biodiversity (n = 15, 35%) 2. Provides spiritual/ recreational/ other ecosystem services (n = 14, 33%) 3. Absence of human modification (n = 6, 14%)
Secondary vegetation (Tokyo, 23 Wards: n = 67) (Vancouver: n = 47)	1.Existing/ familiar scenery (n = 33, 49%) 2.Balance of human and natural features (n = 14, 21%) 3. Humans as part of nature/ obvious evidence of human modification (n = 11, 16%)	1. Original biodiversity (n = 18, 38%) 2. Contributes to increasing biodiversity (n = 14, 30%) 3. Absence of human modification (n = 10, 11%)
Primary vegetation (Tokyo, 23 Wards: n = 44) (Vancouver: n = 61)	1.Existing/ familiar scenery (n = 33, 49%) 2.Original scenery of Tokyo (n = 6, 14%) 3.Still existing in Tokyo (by knowledge) (n = 5, 11%)	1. Original biodiversity (n = 23, 38%) 2. Absence of human modification (n = 15, 25%) 3. Provides spiritual/ recreational/ other ecosystem services (n = 11, 18%)

4.1.4 Scenic aesthetic landscape preference

The second question on landscape preference targeted the landscape categories that respondents believed should be allocated more land area for, within urban areas in the future. This question aims to actualize respondents' behavior towards biodiversity conservation in terms of elucidating if their nature conservation intent is carried forward to actual landscape preference. Landscape selection based on pictorial representations, is a less abstract means in which respondents can assess their environment and is therefore suitable for testing if nature conservation attitudes (at an intention level), correspond to practical behaviors.

In terms of the selection frequency of each individual landscape type, manicured landscapes was ranked as the landscape with the highest selection instances in Singapore and Tokyo (23 Wards) (37% and 32% of the respective sample sizes). However, in the Vancouver dataset, manicured landscapes where ranked as the third highest in terms of selection frequency (19%) after primary (21%) and secondary (22%) vegetation. Similar to the pattern observed in the previous section (4.1.3) where selection frequencies of individual landscape types foreshadows a similar choice when landscape preference was analyzed in categories, this result also mirrors trends within the types of landscape categories selected as ‘preferred’ for increase within urban confines (Table 13).

Table 13: Top three landscape categories which respondents believe should be allocated more land area for in the future in Singapore, Tokyo (23 Wards) and Vancouver.

City	Landscape categories	Percentage	Standardized Residual *[(O-E/) √E]*	Rank
Singapore *Categories shown are only those which tested significant with the Pearson's Chi-squared Goodness of fit test (p<0.05, positive values for [(O-E/) √E] > 2SE (0.911))*	Manicured landscape	20.00	26.89	1
	Manicured landscape + Primary vegetation	15.00	11.52	2
	Manicured landscape + Primary vegetation + Secondary vegetation	12.00	5.01	3
Tokyo (23 Wards) *Categories shown are only those which tested significant with the Pearson's Chi-squared Goodness of fit test (p<0.05, positive values for [(O-E/) √E] > 2SE (1.14))*	Secondary vegetation + Manicured landscapes	17.89	44.97	1
	Manicured landscape	17.25	43.10	2
	Secondary vegetation	6.71	12.18	3
Vancouver *Categories shown are only those which tested significant with the Pearson's Chi-squared Goodness of fit test (p<0.05, positive values for [(O-E/) √E] > 2SE (1.511)). Note that there is no significant third-ranked category in Vancouver*	Primary vegetation + Secondary vegetation + Grassland + Agriculture land + Manicured landscape	21.10	16.63	1
	Primary vegetation + Secondary vegetation	8.23	3.04	2
	Primary vegetation + Secondary vegetation + Grassland + Manicured landscape	8.23	3.04	2

The absence of urban environments in all categories found significant in this part of the analysis could point to consistency with the nature preservation intent which was exhibited by respondents in all three cities. Urban environments, with its prominent representation of impervious surfaces and little amounts of greenery, could have been understood by respondents to represent a clearly opposite effect to achieving biodiversity conservation goals.

However, the lack of urban environments within the landscape categories selected as ‘preferred’ for representation in urban environments still does not paint a completely optimistic picture for urban biodiversity conservation. Despite the obvious intent towards nature preservation in all three cities, landscapes which contributed most to biodiversity conservation were only correctly selected as the preferred landscape types in Vancouver. This was the opposite case in Singapore, where the most preferred landscape was not one which would contribute to achieving maximal biodiversity conservation. The results obtained from the Tokyo (23 Wards) dataset, on the other hand, lay midpoint between the responses from Singapore and Vancouver.

Within the Vancouver dataset, landscape preference (all landscape types with the exception of built areas) perfectly mirrored nature conservation intent and habitat-type irreplaceability values for maximal conservation. Results were less straightforward in the case of Tokyo (23 Wards) where respondents selected for mixture of manicured and semi-naturalistic landscapes (young secondary vegetation and manicured landscape). Landscape preference in Singapore, on the other hand (manicured landscapes) was most inconsistent with nature conservation intent and habitat-type irreplaceability values for maximal conservation.

Landscapes that were widely preferred were found be visually non-complex landscapes. In totality, this has resulted in manicured landscapes being increasingly preferred over naturalistic landscapes in the order of Singapore to Tokyo (23 Wards) to Vancouver. It is interesting to note that visual complexity, when taken on a global perspective, is not a hard-and-fast correlate with the level of human modification, and habitat-type irreplaceability present in the landscape. For example, the visual complexity of a primary cold temperate evergreen forest is much lower than that of a tropical primary forest although both have sound conservation potential within the context of their respective ecological zones.

Results obtained from the Singapore case study differ from previous studies of landscape preference in urban areas, where the general public in temperate and subtropical cities were found to have a neutral preference with regards to naturalistic and manicured landscapes (Herzog, 1989; Jim & Chen, 2006; Özgüner & Kendle, 2006; Bonnes et al., 2011). The results of previous studies however, were relatively consistent within the context of the same ecological zones. Landscape preference in Tokyo (23 Wards) (cool temperate) was split between manicured landscapes and secondary (naturalistic) vegetation while landscape preference in Vancouver was constant throughout all landscape types, excluding urban environments.

Reasons for this selection feature scenic aesthetics as a prominent driver for landscape preference, especially in the case of Singapore (Khew et al., 2014). This is further supported by the visual nature of the landscapes which were selected as being preferred. As mentioned earlier, all the preferred landscapes across the three study sites were non-visually complex and conform to the relatively ordered landscapes that are evolutionarily preferred by humans in lieu of good prospect and refuge opportunities (Parsons & Daniel, 2002).

Dislike for landscapes which are deemed as too complex/ non-aesthetic is reflected by the low actual experience in natural landscapes which appear chaotic and have inherent high biodiversity. Along these lines, only 21.5% of survey respondents in the Singapore dataset had actual frequent (at least annual) experience in a tropical nature reserve. In comparison, 51.8% of Tokyoites and 57.8% of Vancouverites had at least, annually visited the natural landscapes within their ecological zones. These regular visits, could have been possible due to the more aesthetic appearance of natural landscapes in warm and cool temperate zones. This ultimately paints the natural landscape as a place where people are able to experience visual and spiritual relaxation. The lower biodiversity levels not only reinforces the visual coherence inherent in warm and cold temperate forests, but also ensures that visitors have a lower probability of running into potentially unpleasant biodiversity (like mosquitoes or ants in a tropical rainforest). Frequent visits to natural areas by respondents in Tokyo (23 Wards) and Vancouver could then have reinforced perception to be more accepting towards natural landscapes.

Open ended questions recording respondents' [Tokyo (23 Wards) and Vancouver] reasons for selecting landscapes that they believe should be allocated more area for in the future also reflect a relatively aesthetically driven trend(Table 14).The predominant answers that urban residents of these two cities provide for selecting their preferred landscape choice was outstandingly scenic aesthetic based for manicured landscapes - a mainstay in the landscape preference selection of both cities. An explicitly pro-biodiversity conservation slant was only evident in the case of natural landscapes (primary and secondary vegetation) and grassland selection in Vancouver.

Table 14: Summary of top three themes in qualitative responses to landscapes appearing in significantly preferred landscape categories for respondents in Tokyo (23 Wards) and Vancouver.

Landscape type	Tokyo (23 Wards)	Vancouver
Urban areas (Tokyo, 23 Wards: n = 13) (Vancouver: n = 2)	1.Biodiversity (roadside trees visible) (n = 4, 31%) 2.Economic development (n = 3, 23%) 3. Natural human development (n = 3, 23%)	1.Necessary for population growth (n = 2)
Manicured landscapes (Tokyo, 23 Wards: n = 163) (Vancouver: n = 42)	1.Aesthetics enabling spiritual ecosystem services (e.g. stress-relief) (n = 42, 26%) 2. Aesthetics enabling relaxing recreation (n = 21, 13%) 3.Aesthetics: Breaking the visual monotony of the cityscape(n = 15, 9%)	1. Aesthetics: Beautiful landscapes, break monotony of cityscape (n = 21, 50%) 2. Accessible, Public green spaces (n = 4, 9.5%) 3.Feasibility: Second best option in absence of naturalistic vegetation (n = 4, 9.5%)
Urban agriculture (Tokyo, 23 Wards: n = 72) (Vancouver: n = 47)	1.Education for children (n = 3, 21%) 2. Cultural importance (n = 3, 21%) 3. Food security (n = 3, 21%)	1. Food security/ local food products (n = 19, 40%) 2.Support culture of urban agriculture (n = 10, 21%) 3.Shorter food mileage/ reduce global warming (n = 9, 19%)

Rice/ paddy fields (Tokyo, 23 Wards: n = 21)	1.Connection between human and natural systems (n = 4, 19%) 2. Education for children (n = 3, 21%) 3. Cultural importance (n = 3, 21%) 3. Food security (n = 3, 21%)	N/A
Grasslands (Vancouver: n = 42)	N/A	1.Necessary to improve biodiversity (n = 11, 26%) 2.Necessary to conserve what is remaining (n = 9, 21%) 3. Places for play and recreation (n = 4, 10%)
Secondary vegetation (Tokyo, 23 Wards: n = 105) (Vancouver: n = 52)	1.Feasibility: 2nd best option in absence of primary vegetation (n = 14, 13%) 2. Necessary to conserve what is remaining (n = 12, 11%) 3. Prevent global warming/ temperature rise (n = 11, 10%)	1. Necessary to improve biodiversity (n = 15, 29%) 2.Necessary to conserve what is remaining (n = 10, 19%) 3. To allow for succession to primary forest stage (n = 8, 15%)
Primary vegetation (Tokyo, 23 Wards: n = 64) (Vancouver: n = 61)	1.Necessary to conserve what is remaining (n = 17, 27%) 2. Necessary to improve biodiversity (n = 6, 9%) 3. "Correct" form of nature (n = 5, 8%)	1. Necessary to conserve what is remaining (n = 30, 49%) 2. Necessary to improve biodiversity (n = 13, 21%) 3.Necessary for Human-Nature relationship balance (n = 4, 7%)

As such, with the exception of the theme relating to the necessity of improving biodiversity within the landscape [which has emerged prominently in primary, secondary and grassland vegetation in Vancouver, while only appearing in primary vegetation in Tokyo (23 Wards)], other themes are predominantly human-centric. In addition to open-ended responses, the demographic/ cultural background of the respondents, along with the degree of which respondents intended to conserve natural landscapes could help to further explain landscape preference choices. The next section of this chapter aims to shed light on possible demographic and landscape-exposure related factors which could have helped to shape respondents' nature conservation intent and scenic aesthetic landscape preference.

4.2 Predictor factors of nature conservation intent and scenic aesthetic landscape preference

4.2.1 Social factors

Regression analyses were conducted in order to determine demographic factors which significantly affected nature conservation intent and landscape preference among survey respondents in Singapore, Tokyo (23 Wards) and Vancouver. Table 15 shows the results of a multinomial logistic regression on demographic variables affecting preference for landscapes that respondents believe should be allocated more land area for in the future of their respective cities. It is interesting to note that, since the majority of Vancouverites selected all landscapes types (with the exception of urban areas) as their preferred landscapes, there were no significant demographic factors which significantly pushed preference towards naturalistic or manicured landscapes.

Table 15: Results of a multinomial logistic regression on demographic variables affecting preference for landscapes that respondents believed should be allocated more land area for in the future. There were no significant correlations found for the analysis on landscape preference against respondents' demographic variables in Vancouver.

City	Independent Variable	Dependent Variable	β	p-value
Tokyo (23 Wards)	Sex			0.484
	Age	Secondary vegetation + Manicured landscape	-0.184	0.041*
		Manicured landscape	-0.320	0.041*
	Occupation			0.522
	Residence outside the 23 Wards Area for >2 years			0.142
	Residence overseas for >2 years			0.165
	Conservation Classes			0.545
	Frequent (≥ weekly) experience in parks/ gardens	Secondary vegetation + Manicured landscape	0.623	0.030*
		Manicured landscape	-0.308	0.030*
		Pri + Secondary + Manicured landscape	0.548	0.030*
	Experience (≥ yearly) in Zoos and Botanic Gardens			0.831
	Experience (≥ yearly) in nature reserves			0.702
	Experience (≥ yearly) in rural areas			0.125

	Sex			0.630
	Age	Manicured landscapes	-17.615	>0.001*
		Pri + Manicured landscapes	-17.732	>0.001*
		Pri + Secondary + Manicured landscapes	-17.383	>0.001*
	Occupation			0.990
	Residence overseas for >2 years	Pri + Secondary + Manicured landscapes	17.812	0.037*
Singapore		Pri + Secondary + Manicured landscapes	17.119	0. 037*
	Conservation Classes	Pri + Manicured landscapes	18.373	0.028*
		Pri + Secondary + Manicured landscapes	18.596	0.050*
	Summed exposure (≥ once yearly) to gardens, zoos, botanic gardens and nature reserves			0.059

Note: The * symbol denotes categories which were significant at an α level of 0.05.

In both Singapore and Tokyo (23 Wards), correlations were also found between younger age and landscape categories deemed as having a significant preference score, regardless of them being manicured only or including natural landscapes. This implies that there is less variation among answers that younger people give as their preferred landscapes as compared to people of an older age group. There is no straightforward explanation for this phenomenon except for the possibility that younger people in both countries have had less experience in a large variety of landscape types, thereby narrowing their selection choices. Members of the older generation in Tokyo (23 Wards) could have spent substantial time in natural or agricultural landscapes away from the capital. Similarly in Singapore, the older generation could have experienced more natural landscapes within the country before a rapid post-independence drive for urbanization and manicured landscape creation in 1965 (see section 5.1.2.1).

Among survey respondents who indicated preference for both naturalistic and manicured landscapes, policy-targetable factors for increasing acceptance of naturalistic landscapes are conservation education in Singapore and encouraging frequent park-going behavior in Tokyo (23 Wards) (Table 15). Past studies have revealed that conservation education is positively correlated with issues relating to environmental protection and biodiversity conservation (Caro et al., 1994). Respondents who have had such classes in Singapore could have achieved a better appreciation of biotic processes and the vulnerability of natural landscapes in their ecological context (Caro et al., 1994).

Along these lines, it is interesting to note that conservation education did not show up as a significant driver for natural landscape selection in Tokyo (23 Wards). This could be due to the fact that the highest ranked choice for future landscape preference already included secondary (natural landscapes) and manicured landscapes together in the category of the highest preference-rank. It therefore follows that Tokyoites could have an ingrained appreciation of secondary landscapes based on the practical experience of the ecosystem services, especially spiritual and regulating services, provided by secondary and manicured landscapes.

This is in turn, is connected to the result which shows that frequent (more than once a week) park visiting behavior is connected to a higher preference for natural landscapes in Tokyo (23 Wards). Correlating experience to the degree of protection that an individual feels towards natural environments has been relatively established in literature on environmental psychology (Halpenny, 2010). Even across cultures, people have been shown to exhibit conservation tendencies towards landscapes in which they have spent more time within, due to the development of place-attachment and personalization of the given space (Kals et al., 1999; Pooley & O'Connor, 2000).

However, it is interesting to note that frequent park-going behavior resulted in an increased preference towards naturalistic landscapes, although city parks in Tokyo are rightfully classified as being manicured landscapes. As such, preference for naturalistic landscapes could have been a carry-over behavior whereby place-attachment to manicured-green spaces could have resulted in a wider appreciation of nature (Halpenny, 2010; Vaske & Korbin, 2001). Another explanation to this behavior could be that Tokyoites who frequently visit manicured-green spaces already have a predisposition towards an attitude of nature conservation.

Within the Singapore dataset, place attachment could have been exhibited through spending time in more natural landscapes overseas. Countries where respondents were recorded as having stayed long-term in (more than two years) are those where subtropical or temperate natural landscapes can be easily experienced (e.g. Australia, the United States or England). As such, experiencing pristine nature abroad could have been translated into the desire to protect natural areas within Singapore (Khew et al., 2014). This explanation also serves to highlight the existence of a landscape preference limit which hinges on the amount of complexity inherent in a landscape. This limit includes temperate/ subtropical natural landscapes but excludes areas like tropical rainforests, which are too biodiverse and hence, visually not aesthetically appealing. Therefore, though Singaporeans are ready to spend time in natural areas where complexity and diversity are relatively manageable, this might not be a sentiment which is easily transferrable to tropical natural areas.

Respondents' intent to preserve or utilize natural landscapes was also found to be a factor which affected preference for natural landscapes in Singapore and Tokyo (23 Wards). Table 16 shows the results of a multiple linear regression on dimension of nature conservation intent against landscape preference. In this table, categories of preferred landscapes which included natural landscapes as part of their combination, were compared against those without natural landscapes included in their selection. Within the Tokyo (23 Wards) dataset, pro-conservation behavior for the sake of nature in itself (P2) was correlated with landscape preferences which included natural landscapes.

Conversely, the less that Tokyoites wanted to preserve natural landscapes for human benefit (U1), the more likely they were to have a landscape preference which included primary and secondary vegetation. Within the Singapore dataset, the desire to alter natural landscapes for human benefit (U3) was found to be negatively correlated with a preference for natural landscapes. These results suggest that people who prefer a combination of manicured and natural landscapes are also more altruistic in their attitude towards nature as they seem willing to give up aspects of human comfort for the sake of conserving nature.

Table 16: Results of a forward multiple linear regression on dimensions of nature conservation intent against preference for landscapes categories which included natural vegetation (primary and secondary vegetation). There were no significant correlations found for the analysis on independent variables in Vancouver.

City	Independent variable	β	Correlations		d.f	p-value
			Partial	Part		
Tokyo (23 Wards)	(P2) Pro-conservation behavior	0.128	0.194	0.140	311	0.001
	(U1) Pro-conservation behavior (for human benefit)	-0.154	0.144	0.141	310	<0.001
Singapore	(U3) Altering natural landscapes for human benefit	-0.153	-0.240	-0.240	87	0.024

Results show thus far, that preference for natural landscapes is influenced by demographic/ cultural factors [e.g. going more than once a week to parks in Tokyo (23 Wards) and having prior conservation education in Singapore, among others] and an attitude of nature preservation. This suggests the existence of a positive feedback loop between existing pro-nature attitudes encouraging a predisposition towards preference of natural landscapes. This in turn feedbacks into an increased drive for respondents to experience natural landscapes either in person (within their local context or abroad), or through formal conservation-related education. An analysis of the demographic factors which were shown to increase respondents' tendency towards the pro-nature conservation dimensions shortlisted in Table 16, further confirms the existence of the feedback loop between pro-conservation attitudes, natural landscape preference and actual experience in natural landscapes. Results of the forward multiple linear regression, using the P2 and U1 dimensions in the Tokyo (23 Wards) dataset, and the U3 dimension in the Singapore dataset as dependent variables, reveal that exposure is key in the construction of pro-conservation attitudes.

Table 17: Results of a forward multiple linear regression on demographic information of respondents in Singapore and Tokyo (23 Wards) against the dimensions of nature conservation intent found to significantly affect preference for natural landscapes (see Table 16).

City	Independent variable	Dependent variable	β	Correlations		d.f	p-value
				Partial	Part		
Tokyo (23 Wards)	Summed exposure	(P2) Pro-conservation behavior	0.054	0.181	0.181	311	0.001
	Age	(U1) Pro-conservation behavior (for human benefit)	0.101	0.291	0.291	312	<0.001
Singapore	Summed exposure	(U3) Altering natural landscapes for human benefit	-0.149	-0.225	-0.225	87	0.035

Age was found to affect pro-conservation behavior primarily for human benefit (U1) in Tokyo (23 Wards), where older residents were more likely to conserve nature only because of the benefits humans can possibly derive from it. It is currently unclear why the older generation within the Tokyo (23 Wards) dataset exhibits a slightly lower tendency towards wanting to preserve nature. This result is interesting in light of earlier findings were younger people in Tokyo were found to be more decisive in their preferred landscape choices that included both natural (secondary vegetation) and manicured landscapes (Table 15). The same possible explanatory factor that the elder population in Tokyo could have spent a substantial portion of their youth within rural areas in Japan could be employed here as well. In this case, the elderly could have had a more widely differing view which includes concepts ranging from utilitarianism (e.g. valuing provisioning services like food crops and livestock) or ecocentric (e.g. nature needing to be valued for its own sake). The younger population, which has primarily been brought up in Tokyo (23 Wards), could have had a more romantic view of nature.

Another factor: summed exposure, was found to be correlated to increased nature preservation intent in terms of pro-conservation behavior (P2) in Tokyo (23 Wards) and was correlated negatively to the tendency to alter natural landscapes for human benefit (U3) in Singapore. In the case of the survey conducted in Singapore, summed exposure was the sum of the following activities: yearly visits to the botanic gardens, nature reserves or to the zoo, attendance at a lecture on an ecology/ conservation topic and being a member of an environmental organization. In the case of the Tokyo (23 Wards) dataset, summed exposure was the sum of the following: visits to the park for festivals (e.g. the practice of *hanami* in spring to observe sakura flowers in bloom), weekly visits to the parks and yearly visits to the zoo, nature reserves or countryside areas. As such, people who tended to spend time doing activities related to nature appreciation at an experiential, conservational or scientific level were again shown to exhibit a higher intent towards natural landscape preservation.

This result reflects the rather established trend whereby an increase in exposure and experience with nature could result in the tendency to relate to, and thereby protect natural landscapes by extension (Vaske & Kobrin, 2001). In the case of this study, the respondents in Tokyo (23 Wards) and Singapore who have exhibited preference for natural landscapes could have done so based on personal experience within the landscapes itself. Earlier, it was shown that Tokyoites who visited a manicured park frequently tended to have a landscape preference which encompassed naturalistic landscapes. A plausible explanation given to this behavior was that Tokyoites who frequented manicured-green spaces already have a predisposition towards an attitude of nature conservation, thereby reinforcing the "carry-over" desire to preserve natural landscapes, despite interacting on a daily basis with manicured landscapes instead.

This study thus further supports the existence of a positive feedback loop between existing pro-nature attitudes, experience in nature and preference of natural landscapes. In brief, this loop exists between the following factors in Singapore and Tokyo (23 Wards):

- **Singapore:** A positive feedback loop exists between the factors of: conservation education, spending time in natural landscapes abroad, younger age, and desire against altering nature for human comfort and natural landscape preference.
- **Tokyo (23 Wards):** A positive feedback loop exists between the factors of: frequent visits to manicured parks, younger age, pro-conservation behaviour for nature's sake and natural landscape preference.

It is therefore useful to look at these factors as a whole in order to promote appreciation of natural landscapes within urban confines, especially in the case of tropical cities such as Singapore and cool-temperate cities similar to Tokyo (23 Wards).

4.2.2 Potential daily exposure to manicured and naturalistic landscapes

In order to investigate if nature conservation intent and landscape preference held by respondents in all three study cities were affected by the amount of natural and manicured landscapes they were exposed to on a daily basis, a land-use analysis was conducted to elucidate significant differences between these two landscape types at a neighborhood level. Figures 11, 12 and 13 show land use in four 0.3 by 0.3 decimal degree grids that were randomly selected for analysis in each of the study cities.

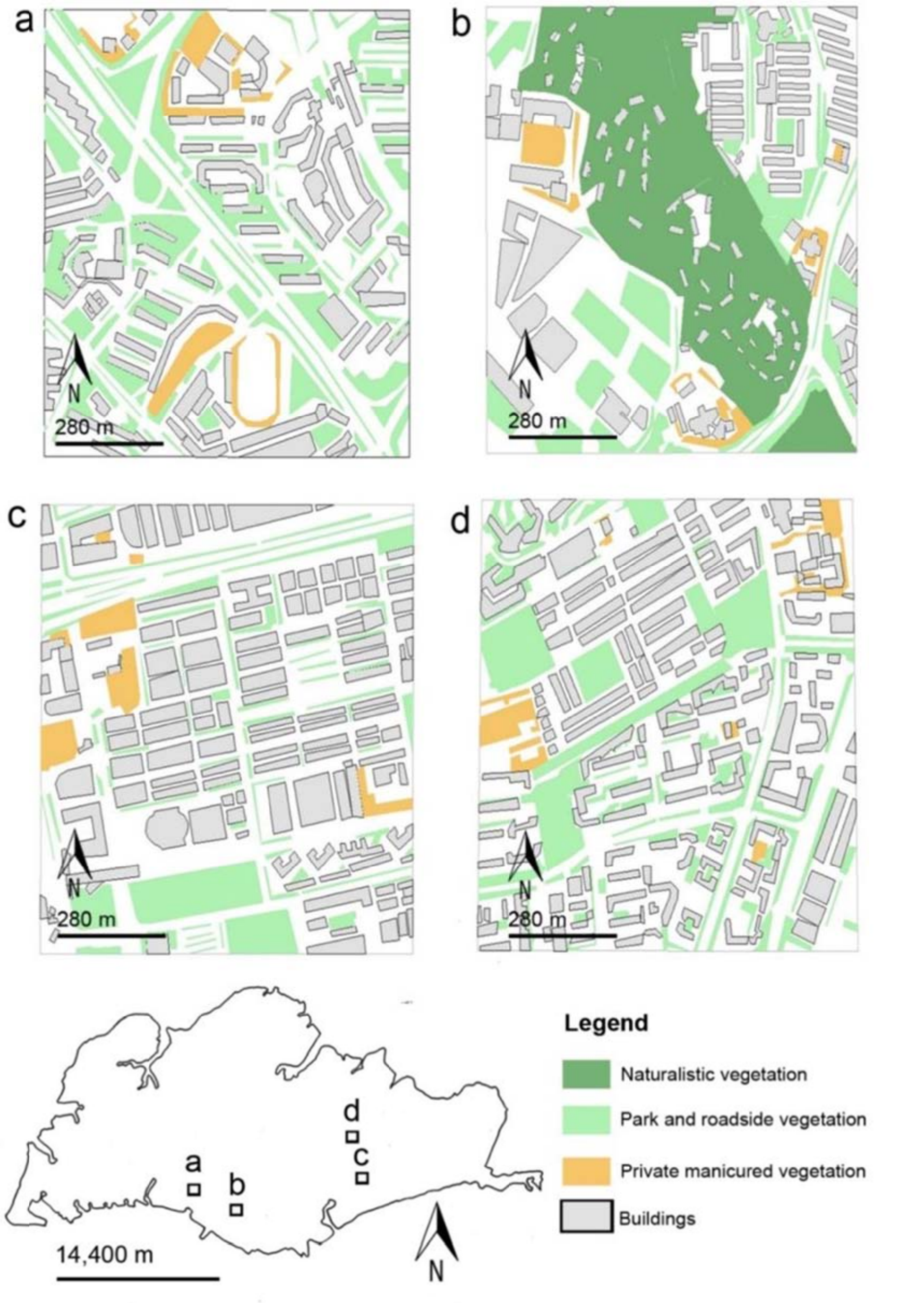


Figure 11: Land use and location of four 0.3 by 0.3 decimal degree grids in Singapore. Each grid represents a land use analysis conducted at a neighborhood scale.

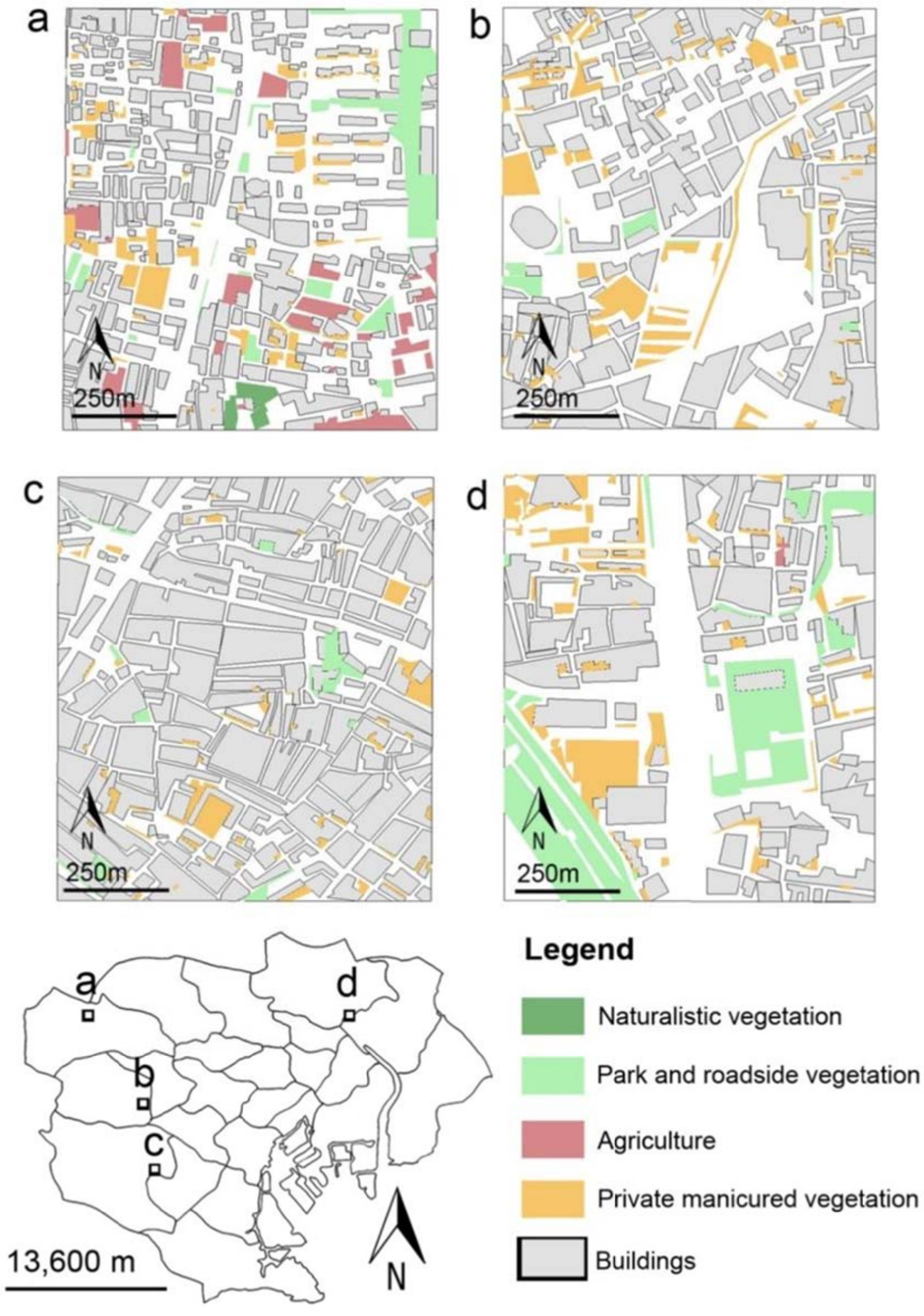


Figure 12: Land use and location of four 0.3 by 0.3 decimal degree grids in Tokyo (23 Wards). Each grid represents a land use analysis conducted at a neighborhood scale.

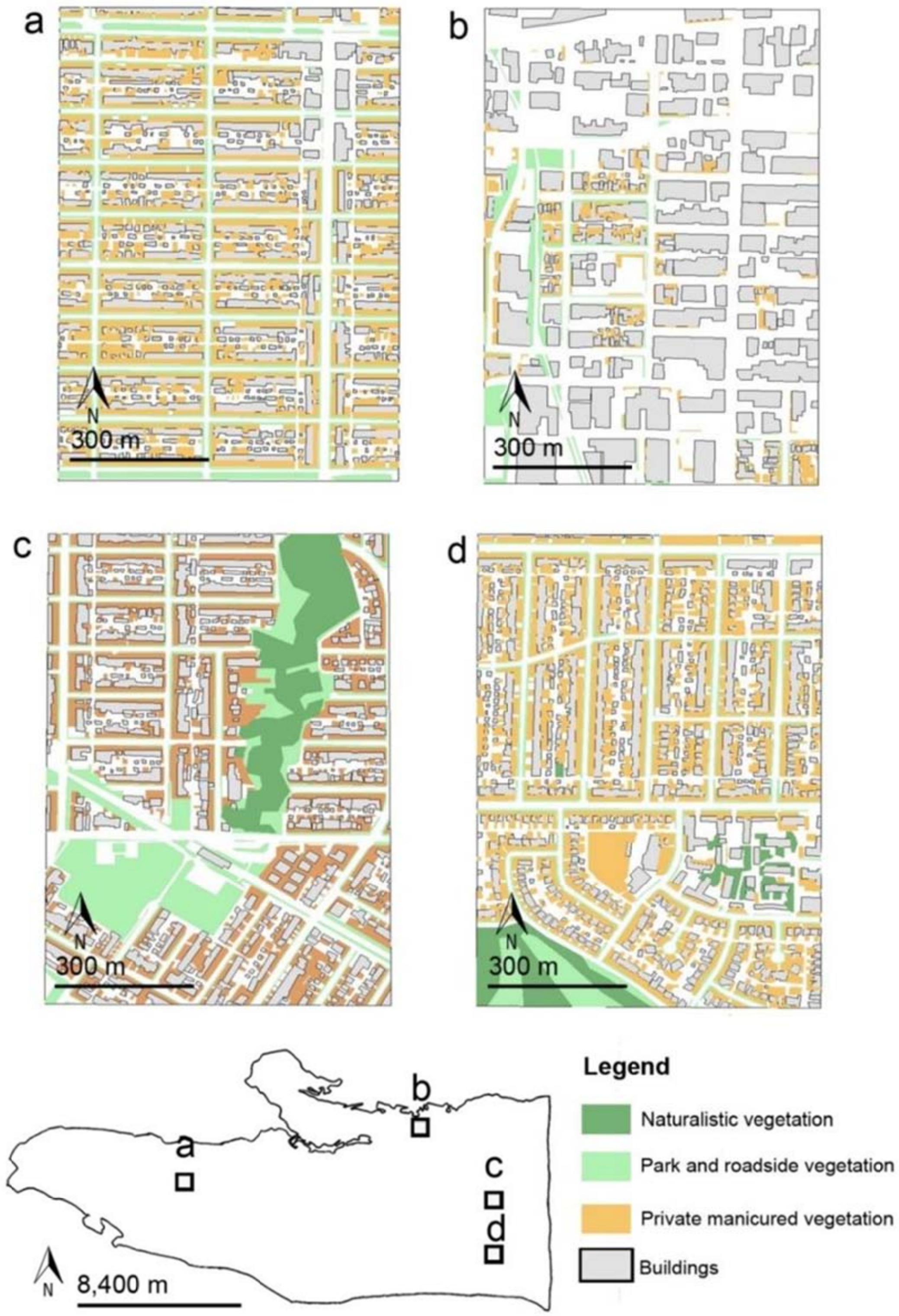


Figure 13: Land use and location of four 0.3 by 0.3 decimal degree grids in Vancouver. Each grid represents a land use analysis conducted at a neighborhood scale.

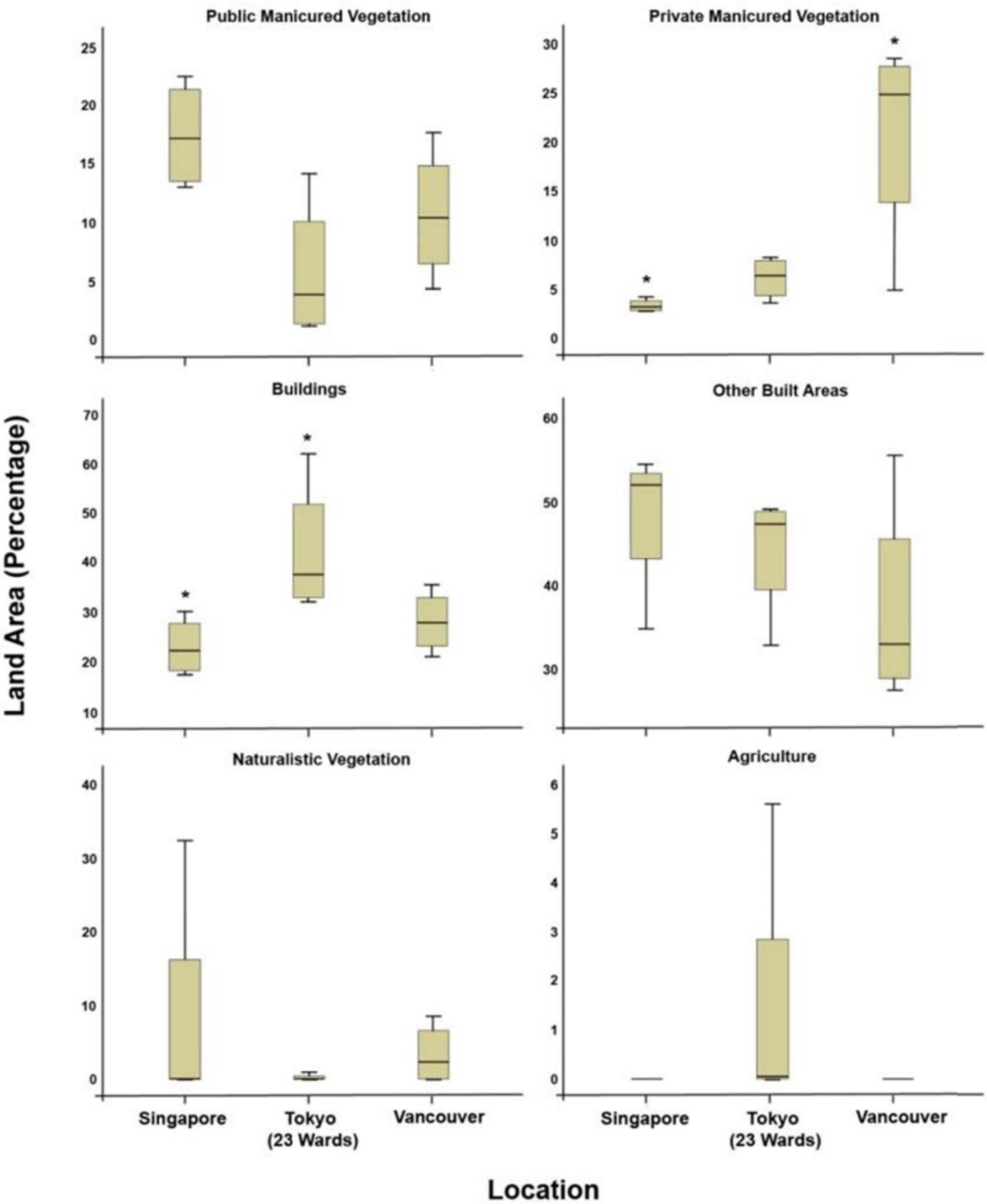


Figure 14: Graph showing significant differences in land uses between Singapore, Tokyo (23 Wards) and Vancouver. (*) symbols represent significant differences of a Kruskal-Wallice analysis with a Mann-Withney U posthoc test at an α = 0.05 significance level.

Results of the land-use analysis on the amount of manicured and naturalistic landscapes available to a typical resident at a neighborhood-level in the three study sites revealed no overall significant differences, thereby excluding *potential* exposure as an explanatory driver of landscape perception. Figure 14 shows the results of a Kruskal-Wallis analysis on significant difference in areas using the average of all land uses in the four grids.

Significant differences were only found between the built areas in Singapore and Tokyo (23 Wards) and private manicured vegetation in Singapore and Vancouver. However, since private vegetation cannot be accessed by the general public, such differences in areas were not taken to be significant in affecting landscape preference on a national level. It is interesting to note that even with equal opportunities for exposure to nature at a neighborhood level, landscape preference for natural landscapes differ significantly between the three study sites.

Results of this section lend further support to the existence of a landscape preference limit which hinges on the amount of complexity inherent in a landscape - an index which is tied to scenic aesthetics and biodiversity. Despite equal opportunities to access naturalistic green-spaces, the higher species-richness which results in tropical naturalistic landscapes could have resulted in the landscapes appearing biotically and visually uninviting. This could then have contributed to the prevention of majority of the survey respondents from visiting natural landscapes in the Singapore dataset, and to a lesser extent, respondents in the Tokyo (23 Wards) dataset (regardless of respondents holding a positive nature conservation intent)..

4.3 Summary:

This chapter shows the complex relationship that urbanites in Singapore, Tokyo (23 Wards) and Vancouver have with nature at the levels of attitude (natural conservation intent), actual behavior (scenic aestehtic landscape selection).

A) Section 4.1

- In all three study sites, respondents had significantly higher nature conservation intent as compared to the intent to utilize nature (section 4.1.2). Respondents in Singapore and Vancouver also selected natural landscapes as being a significant part of their construct of nature (section 4.1.3).
- However, preferred landscapes did not totally match nature conservation intent and the landscapes which respondents' believe should be seen as "nature" across all study sites.
- Selection of preferred landscapes only coincided with landscapes with the highest habitat-type irreplaceability values in Vancouver. Tokyoites' and Singaporeans' preferences were less consistent and inconsistent with habitat-types best suited for conservation [Tokyo (23 Wards): secondary and manicured landscapes; Singapore: manicured landscapes].
- Reasons driving landscape selection were given to be predominantly aesthetic for manicured landscapes (a mainstay in landscape preference results) in all three cities, with the exception of Vancouverites citing biodiversity conservation as an additional motivator in the case of natural landscapes (primary and secondary vegetation).

B) Section 4.2:

- The following respondent demographic factors were found to be correlated with an increased preference for natural landscapes and a higher nature preservation score: **(Singapore)**: conservation education, spending time in natural landscapes abroad, younger age, desire against altering nature for human comfort and natural landscape preference. **(Tokyo, 23 Wards)**: frequent visits to manicured parks, younger age, pro-conservation behavior for nature's sake and natural landscape preference (section 4.2.1).
- Potential daily exposure to natural and manicured landscapes at a neighbourhood level was not a significant factor in influencing respondent's landscape perception (section 4.2.2).

C) Taking A) and B) into account, Figure 15 presents a diagrammatic summary of how it thus appears to be easier to conserve biodiversity within ecological and social limits in the order of Vancouver, Tokyo (23 Wards) and Singapore. More about the conservation potential/ habitat-type irreplaceability of manicured and urban landscapes as compared to natural landscapes in each study site can be found in Chapter 3 of this thesis.

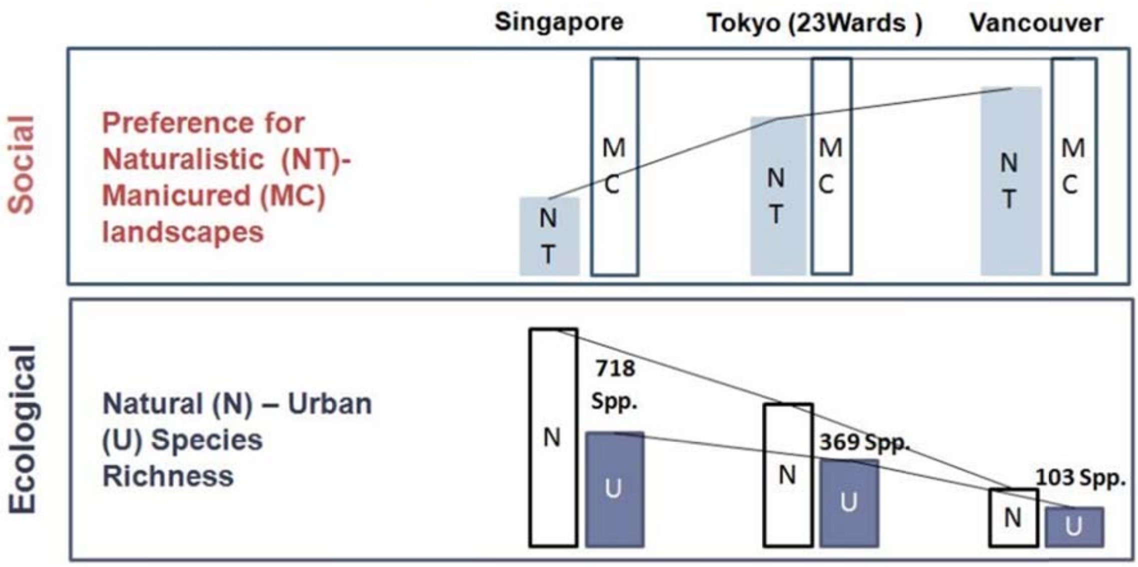


Figure 15: Diagrammatic summary of the integration of social and ecological results found in this study. It is comparatively easier to conserve urban biodiversity within ecological and social limits in the order of Vancouver, Tokyo (23 Wards) and lastly, Singapore.

5. THEORTIECAL IMPLICATIONS

5.1 City-specific socio-ecological uniqueness

Insofar as landscape planning remains intertwined with prevalent social needs, planning cities is no longer limited to addressing urban sprawl and creating an organized urban form (Yokohari & Khew, in press). Since the 1980s when environmental concerns formed a prominent part of the global agenda, the focus of the landscape planning discourse has changed to one of planning resilient and sustainable cities (Satterthwaite, 1997). Cities of today have to tackle issues which enable the maximization of human comfort while minimizing environmental impact (Satterthwaite, 1997). When discussing the integration of the natural and built environments, prominent individuals in the field of landscape ecology have addressed city planning around two co-evolving principals which sometimes conflict with each other. These two principals are:

1) Helping rural biodiversity: minimizing the impact of “the city” on “nature” by limiting the extent of built areas and

2) Helping urbanites: Combining the benefits of “nature” and “the city” by incorporating some natural elements into built areas.

From the 1980s to the 1990s, there were attempts to address both principals in tandem (Leitão & Ahern, 2002). As a result, compact cities with allowances for green spaces and which simultaneously left room for rural nature reserves were conceptualized. Reasons for this point to a planning-response to problems associated by declining urban quality (i.e. increased air pollution) linked to industrialization and the realization that humans were abusing the use of finite natural resources (Leitão & Ahern, 2002). These modern urban planning practices originated mostly from developed countries in Europe and North America (Cillers et al., 2004), spearheaded by big-names such as Richard Forman and Ian MacHarg (Leitão & Ahern, 2002). Aided by a global economic machine of multinational corporations, their ideas soon took shape in cities throughout the world.

However, urban areas soon exploded throughout the world, rendering the first of the two principals more and more unattainable. This posed problems for the function of green spaces within cities. Initially conceptualized for an aesthetic and functional role (i.e. functioning as the green lungs of cities, green spaces were never intended to fully replace the surrounding natural landscape in terms of conservation and connecting humans emotionally to a broader sense of nature. However, despite the changing circumstances that cities are currently facing, the role of green spaces in cities has yet to be redefined. As a result, cities of today are seen as being completely alienated from nature and devoid of any potential to contribute to the first original principal of urban planning – conserving biodiversity.

Another problem facing the planning of sustainable cities in the 21st century could have been caused by the initial way that cities have been conceptualized. As globally prominent urban planning measures originated mainly from USA and Europe, the way that green spaces have been created throughout the world has been relatively uniform, despite the social and ecological uniqueness of different cities. These practices focus mainly on the establishment of manicured urban green-spaces (The Biodiversity Conservation Strategy Partnership 2008; Biodiversity Strategy Office, Tokyo 2009; Hostetler et al., 2011).

However, as evidenced in Section 3 and 4 of this thesis, adopting an increase in green-space cover as an across-the-board practice may not be as effective for biodiversity conservation in tropical and warm temperate cities as they are in cold temperate cities. Besides the two former locations having a significantly different biodiversity profile (Chapter 3), the way in which nature conservation intent and scenic aesthetic valuation of landscapes interact within the social indicator of landscape preference also differs greatly between cities in these three ecological zones.

5.2Complexity-determined preference limit: Species-richness, nature conservation intent and scenic aesthetic landscape preference

As mentioned in the beginning of chapter 4, the main purpose of conducting the landscape perception questionnaire in this thesis was to elucidate understand how landscapes with varying degrees of visual human modification and hence, biodiversity conservation potential were evaluated. Also, in Section 1.4.2 (academic gap in the social aspect of measuring urban biodiversity conservation) and section 1.5. (research purpose), it was mentioned that the results of the questionnaire were to especially elucidate the relationship between nature conservation intent (landscape level) and scenic aesthetics as separate drivers for landscape preference.

In Singapore, Tokyo (23 Wards) and Vancouver, respondents had significantly higher nature conservation intent as compared to the intent to utilize nature. However, selection of preferred landscapes only coincided with landscapes with the highest habitat-type irreplaceability values in Vancouver. Tokyoites' and Singaporeans' preferences were less consistent and inconsistent with habitat-types best suited for conservation [Tokyo (23 Wards): secondary and manicured landscapes; Singapore: manicured landscapes]. Furthermore, from open-ended questionnaire answers and interview responses, reasons driving landscape selection were given to be predominantly aesthetic for manicured landscapes (a mainstay in landscape preference results) in all three cities, with the exception of Vancouverites citing biodiversity conservation as an additional motivator in the case of natural landscapes (primary and secondary vegetation). Furthermore, results of a land-use analysis on the amount of manicured and naturalistic landscapes present at a neighborhood-level in the three study sites revealed no overall significant differences, thereby excluding *potential* exposure as an explanatory driver of landscape perception.

In light of the above findings, there is a possibility that nature conservation intent functions less as a predictor of landscape preference than scenic aesthetics in tropical and warm temperate cities like Singapore and Tokyo (23 Wards). This could be due to the existence of a landscape "complexity preference limit" inherent in urban dwellers, where landscapes having too much biodiversity are deemed as visually chaotic and potentially unpleasant. A diagrammatic representation of how the "complexity preference limit" is tied into landscape preference, and species-richness is provided in Figure 16.

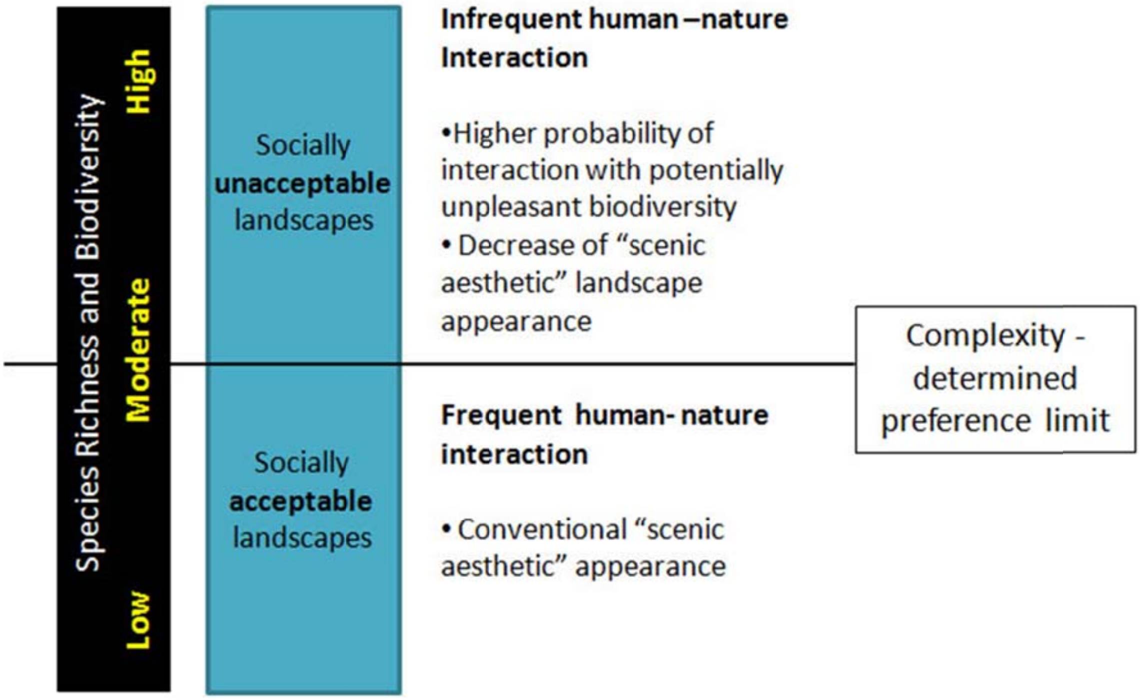


Figure 16: Conceptual diagram showing the interaction between two factors (complexity-determined preference limit and species richness/ biodiversity) that determine if landscapes are acceptable to city dwellers.

When placed into the context of ecological data obtained in this research, wider structural and microclimatic differences between natural areas and areas with a high level of human modification in the case of tropical cities (as compared to their temperate counterparts), could result in only manicured landscapes being accepted by the general public in tropical cities (Figure 17).The ecological results presented in this thesis (Chapter 3) highlights the natural baseline characteristic of extremely high red-list species-richness within natural tropical landscapes and the relatively lower species-richness in cool and warm temperate natural landscapes. Accordingly, across all three cities, preferred, non-complex landscapes were those that contain moderately high levels of unique red-list species (around 300 unique red-list species).

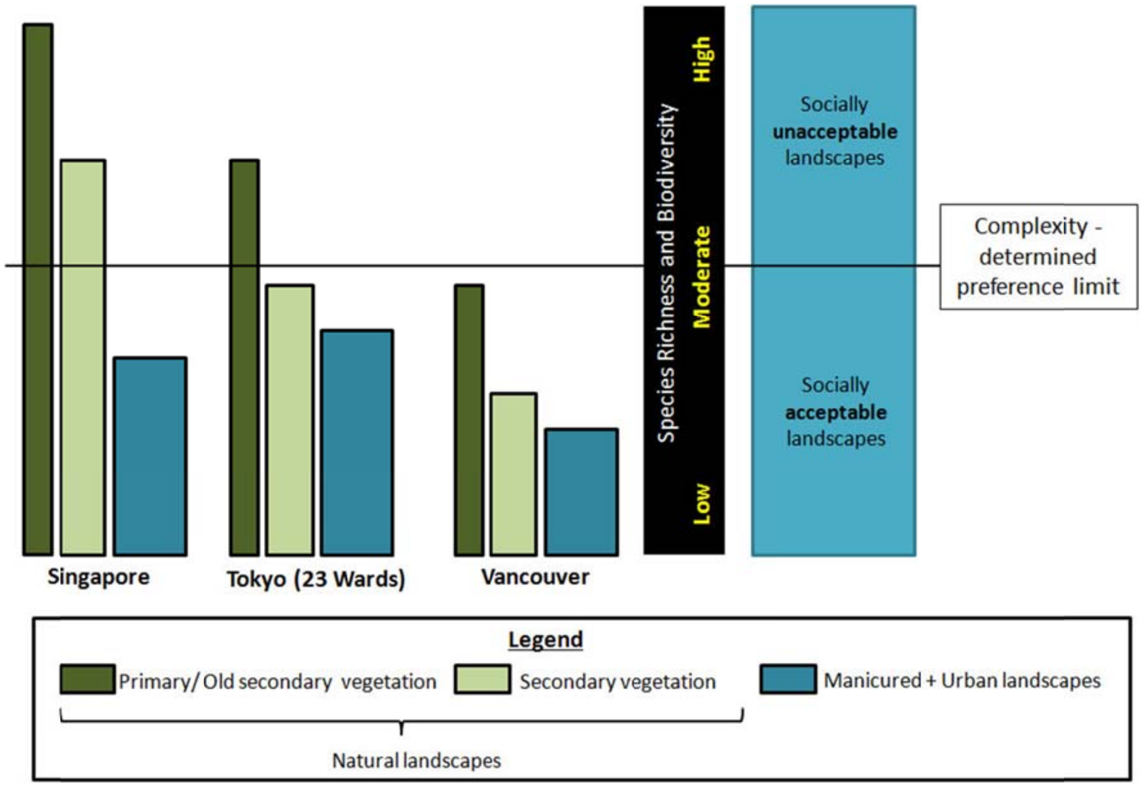


Figure 17: Conceptual diagram showing how ecological data of the three study sites fit into the conceptual landscape acceptance model. In lieu of the sheer amount of diversity in tropical cities like Singapore, naturalistic landscapes automatically fall into the "unacceptable" category. However, natural landscapes with very high conservation capability in the context of warm-temperate and cool-temperate cities [i.e. Tokyo (23 Wards) and Vancouver], fall within the range of acceptable landscapes. The thickness of each landscape bar represents its current land-area within each respective city. Data on the percentage areas taken up by each respective landscape type can be found from the land use maps in figures 3 – 5 [Singapore: Yee et al., 2011; Tokyo (23 Wards): Ministry of Environment, Tokyo, 2003; Vancouver: Simon Fraser University, 2006].

The "complexity preference limit" is connected to species-richness in a landscape in such a way whereby higher species-richness could result in landscapes being non-scenic and containing a higher number of (and a higher chance of encountering) unpleasant biodiversity. Accordingly, due to the significantly higher diversity present in tropical natural areas (e.g. primary rainforest), the resultant landscape may appear unattractive. Chances whereby a person could encounter unpleasant biodiversity is also higher in tropical as compared to cool and warm temperate forests. This interaction between ecological zone specific species-richness and the perceived and visual danger and attractiveness of natural landscape types might thus have been a factor in confining experience in tropical naturalistic areas in Singapore, as compared to Tokyo (23 Wards) and Vancouver. Furthermore scenic aesthetics in Singapore, and pleasant experiences in manicured and natural landscapes Tokyo (23 Wards) were cited as reasons driving the majority's landscape choices. Therefore, ensuring that landscapes lie within the "complexity preference limit" is terms of scenic aesthetics could be the most important factor for determining urbanites' experience in green-spaces.

Although this does not bode well for re-posing cities for conservation in the tropics, it is optimistic to know that this situation is reversed midway and completely in Tokyo (23 Wards) and Vancouver. As such, there is actually substantial potential in Tokyo (23 Wards) and Vancouver to use cities as landscapes for conservation. This study thus prompts a re-thinking of the usefulness of urban areas for biodiversity conservation and the reconnection of humans with their natural surroundings.

Furthermore, the placement of the landscape complexity-determined preference limit with respect to natural and manicured landscapes in the three study sites could be the result of local planning histories. The next few sections (section 5.1.1.1 to 5.1.1.3) aim to provide a historical urban-planning context to explain the resultant human-nature relations and hence, the placement of the complexity-determined preference limit within each study site.

5.2.1 Urban planning and the re-orientating of human-nature relations

5.2.1.1 Singapore: Purposeful manicuring

The clearing of Singapore's natural vegetation (evergreen tropical forests and mangrove forests along the banks of coastal areas) started from the early 19th Century to just before 1965 (Kong & Yeoh, 1996). This clearing was done to make way for agricultural land (mainly rubber and gamibr plantations) when the country was a British colony (Corlett, 1988; Kong & Yeoh, 1996). At the end of the British Colonial rule after World War II (1945), what remained of Singapore's primary forest was limited to just 10% of Singapore's land area while agriculture plantations covered about half of the country's land (Wong, 1969).

After the exit of the British from their colonies in Southeast Asia after World War II, postwar Singapore was briefly merged with Malaysia. Separation eventually occurred in 1965, and as an independent nation with a small land area and limited capacity natural resources, the newly independent government started to re-orient land use in the country towards the development of business, industrial and residential districts (Kong & Yeoh, 1996). Green-spaces in Singapore was viewed with a very economic-slant, resulting in 99% of Singapore's natural tropical forests being cleared for urbanization (Corlett, 1992; Corlett, 1997) and the creation of manicured landscapes with ornamental, exotic plants (Kong & Yeoh, 1996). Furthermore, manicured landscapes were arguably included in the city's planning for an economic motive – the creation of a "garden city" image for the attraction of foreign investment in the way of business and tourism (Tan, 2009).

The 1990s to the present highlight a slight shift in the way green-spaces were perceived in Singapore. Alongside the popularization of environmental awareness and the use of the term "sustainability" in the late 1980s, there was increasing local discourse on protecting local biodiversity (Savage & Kong, 1993). This period saw the creation of nature reserves (e.g. the Sungei Buloh Wetlands Reserve and the Labrador Park Nature Reserve) (Kong & Yeoh, 1996).

However, it could be argued that the attention paid to biodiversity conservation might have been too late. The majority of Singaporeans still could hold on to an aesthetic preference for landscapes and an idealized construct of what nature should be, as evidenced in Sections 3 and 4 of the thesis. The majority of Singaporeans today have not experienced natural landscapes within their country's context and much of their experience is with manicured landscapes and urban areas which cover more than 50% of the country (Corlett, 1992; Corlett, 1997).

5.2.1.2 Tokyo (23 Wards): Integrated rural-urban land use

In Japanese cities, urban built areas have traditionally been interspersed by secondary forests and agricultural land since the Edo-era (Yokohari et al., 2010). There was a functional reason to the existence of a mixed urban-rural land use - farmers in the city were able to recycle night-soil for fertilization of their nearby farmlands, and agricultural products could be easily transported back to local markets (Yokohari & Amati, 2005). This system improved sanitation in Japanese cities and even allowed about 1 million people to reside in relative comfort in Edo city as of 1721 (Gordon, 2003), making the city one of the largest in the world at that time. This mixed land use persisted till the middle of the 19thCentury, where 40% of land within Edo city was dedicated to paddy fields, crop fields and tea orchards (Fuji et al., 2002).

However, as mentioned earlier in Section 5.1, the popularization of urban planning movements which relied heavily on the creation of compact cities and zoning into distinct urban and natural land uses started spreading, in a non-contextualized manner to cities such as Japan and Seoul (Ishida, 1992; Leitão & Ahern, 2002; Yokohari & Amati, 2005). A prominent result of Japan's adoption of the western urban planning ideal was the attempt to create a greenbelt around Tokyo, in order to restrict the growth of urban areas (Ishida, 1992). The 1968 City Planning and Zoning Act was also enacted in order to separate the existing rural and urban land uses in order to "tidy up" the appearance of the city.

Under this act, there were attempts to convert historically existing farmland and accompanying tracts of secondary vegetation into urban use (Yokohari & Amati, 2005). However, this was only partially successful for a variety of reasons, as stated below:

1) Farmers did not want to sell their farmland because of a culture that promotes the retainment of family-owned land over generations (Fukutake, 1967).
2) Even during the 1968 City Planning and Zoning Act, land development regulations existed that allowed farmers to subdivide and sell parts of their farmland at urban prices, but with no requirement to provide urban services (Hanayami, 1986; Mori, 1998).
3) The high lobbying power of the Farmers Lobby over the Liberal Democratic Party of Japan ensured that farmers were successful in obtaining attractive tax reductions on

farmland in urban areas, making more economic sense in maintaining farmlands (Sorenson, 1999).

This partial success of the adoption of the zoning and compact city policies from the west has resulted in a mixed rural-urban land use existing throughout Tokyo even today. As much as 3% of the land in Setagaya, one of the 23 Wards in Tokyo, is dedicated to agriculture and the remnants of secondary landscapes (Yokohari & Amati, 2005). This urban planning history could just be the factor that has resulted in the "silver lining" for urban biodiversity conservation in Japan. As a result of a history whereby humans have been exposed to semi-natural landscapes, Tokyoites are more accepting of familiar secondary landscapes in their vicinity. This is a heartening trend, though slightly ironic, as it may be the time to dissociate from western planning strategies and instead, increase attention back on Japan's traditional past.

5.2.1.3 Vancouverism

"Vancouverism" has become a brand name for sustainable urban planning (Walsh, 2013) and it is used as the term to describe the urban planning movement in Vancouver from its outset in 1886. Since Vancouver's founding, natural forest areas were heavily logged. However, upon the establishment of the City of Vancouver Parks Board in 1888, a large area called Stanley Park (about 4 square kilometers) was established (Walsh, 2013). Instead of conducting heavy manicuring of the park, the wealthy residents in Vancouver, ensured that Stanley park was kept natural for their exclusive enjoyment (Walsh, 2013). As the city experienced industrialization, there was increasing public demand to allow public access to the park for recreational use

(McDonald 1984). As a result, this heralded the hiring of notable designers who were tasked with first, improving the accessibility of Stanley park, and then, improving the condition of Vancouver city through the industrialization period.

These planners began with Thomas Mawson in 1910 (McDonald 1984) who started to plan the close integration of naturalistic landscapes within the urban fabric. Mawson's work focused strongly on capitalizing on building a connection between Vancouverites and their surrounding natural landscape, which he viewed as a unique resource to be treasured and appreciated (Walsh, 2013). Drawing heavily from Ebenezer Howard's "Garden City" concept, his work was involved in creating manicured green-spaces which were accessible to the public. However, this work was deemed too costly during the early 1910s (Walsh, 2013) and was thus halted.

Harland Bartholomew later took over city planning after World War II, ensuring a complete shift towards the creation of the industrial city where green spaces were given less prominence (Walsh, 2013). This resulted in the proliferation of urban problems typical to an industrial city such as heavy air pollution. Eventually protests ensured that the planning department was replaced with a new regional planner (Harry Lash) in 1968, who reverted back to Mawson's initial ideas of human-nature integration (Harcourt &Cameron, 2009).

Therefore, it was over the course of Vancouver's history two major distinct elements which constituted "Vancouverism" emerged (Kataoka, 2009; Walsh, 2013):

1) High rise towers which were not densely packed together. Spaces between the towers were filled by shorter (two to three stories tall) row houses. This enabled the inclusion of ground level semi-private gardens for residential and public enjoyment. The high rise towers were constructed in two growth spurts (1956-1973 and 1989-2011). The main reason why the towers were not densely packed together was to ensure an undisrupted view of the surrounding natural habitats (e.g. forests and mountains). The formation of a building bylaw (no. 3575) on the 15th of November, 1954 ensured that building heights, vertical angles and placement, as well as the interior design have to conform to a strict regulation that would both enable inhabitants and street-level pedestrians to adequately view the natural landscape surrounding the city of Vancouver. This was further aided by the development of 27 view cones (1989) where building heights are restricted to protect views of the North Shore Mountains and surrounding water bodies.

2) High density urban living integrated with readily accessible public parks. Parks were designed to maximize human interaction with natural as well as cultural landscapes. Public art (e.g. sculptures) and fountains were featured as prominently as street tree networks and green spaces. Walkways through parks were designed so that a continuous urban network was developed, connected by a continuous canopy of street trees.

Throughout Vancouver's history, there is a recurring theme of reverence for, and ensuring access to the surrounding natural environment. This type of highly integrative human-nature design could have resulted in Vancouverites having a landscape preference which included naturalistic as well as manicured landscapes in this study. Fortunately, biodiversity can also be found in relatively even species-richness across all landscape types.

5.3 Summary: Contextualizing urban biodiversity conservation and its implications for theory

The social and ecological results obtained in this thesis was integrated with discussions pertaining to the prevailing, dominant western-orientated landscape planning movement, and with landscape planning histories in the context of each study site. Within the resultant discussion, the main theoretical recommendations are outlined as follows:

A) Section 5.1: Adopting an increase in green-space cover as an across-the-board practice may not be as effective for biodiversity conservation in tropical and warm temperate cities as they are in cold temperate cities. Besides the two former locations having a significantly different biodiversity profile, the way in which nature conservation intent and scenic aesthetic valuation of landscapes interact within the social indicator of landscape preference also differs greatly between cities in these three ecological zones.

B) Section 5.2: The conceptual discussion inspired by the results show that there could be a landscape complexity-determined preference limit on landscapes that are deemed socially acceptable to urban dwellers. This limit is directly proportional to species richness and hence, biodiversity of a landscape. The complexity-determined preference limit functions as a social indicator which determines the likelihood that an urbanite would spend time in a green-space. Should the scenic aesthetics and biodiversity level of a given green space lie below the complexity-determined preference limit, it would be frequently visited.

C) Section 5.2.1: There is need to re-frame cities as areas with a significant potential for biodiversity conservation as naturalistic landscapes in Tokyo (23 Wards) and Vancouver fall within this preference limit. Reasons for this point towards a "baseline" ecological condition whereby natural landscapes in warm and cold temperate regions are not as biodiverse (and hence, not as visually chaotic) as natural landscapes in tropical regions. Also, urban planning histories of the three study cities [Singapore, Tokyo (23 Wards) and Vancouver] have also worked together to shape residents perceptions of natural and manicured landscapes in their vicinity.

> C1) Tokyo (23 Wards) has had a history of integrated urban-rural land use plan. Tokyoites could thus be used to having secondary landscapes as part of the urban landscapes and could have developed a familiarity with such landscapes
>
> C2) Similarly, Vancouver has had a history of urban planning which ensures the experience of natural landscape even within urban boundaries.
>
> C3) Singapore on the other hand, has had an urban planning history which has actively promoted manicuring green-areas within the urban fabric. Local exposure to natural areas has also been limited as much of the natural land has been cleared for urbanization.

6. PRACTICE- BASED RECOMMENDATIONS

In light of thesis findings and the theoretical recommendations in Chapters 3 to 5, Vancouverites exhibited a "best case scenario" whereby preferred landscapes coincided with landscapes with the highest habitat-type irreplaceability values (natural and manicured landscapes). Tokyoites' and Singaporeans' preferences were less consistent and inconsistent with habitat-types best suited for conservation (Tokyo: secondary and manicured landscapes; Singapore: manicured landscapes). The results of this study therefore elucidate city-specific social and ecological uniqueness. In accordance with prevailing social preference and habitat-type irreplaceability, it is easier to naturalize urban landscapes and conserve red-list species by default in Vancouver, as compared to Tokyo and Singapore (most difficult). This highlights the need for practical recommendations for contextualizing urban biodiversity conservation, especially in non-complex landscapes (i.e. manicured landscapes) in Singapore and Tokyo (23 Wards).

Recommendations can be targeted from a social or ecological front where social recommendations focus on raising the acceptance of natural landscape features within urban confines (i.e. targeting the increase of the complexity preference limit). Ecological recommendations, on the other hand, focus on increasing the ecological quality, or the conservation capacity of landscape types that are already socially accepted but without changing the visual qualities which made them appealing in the first place. Figure 18 shows a summary of how social and ecological recommendations can be framed, within the theoretical framework provided by this thesis.

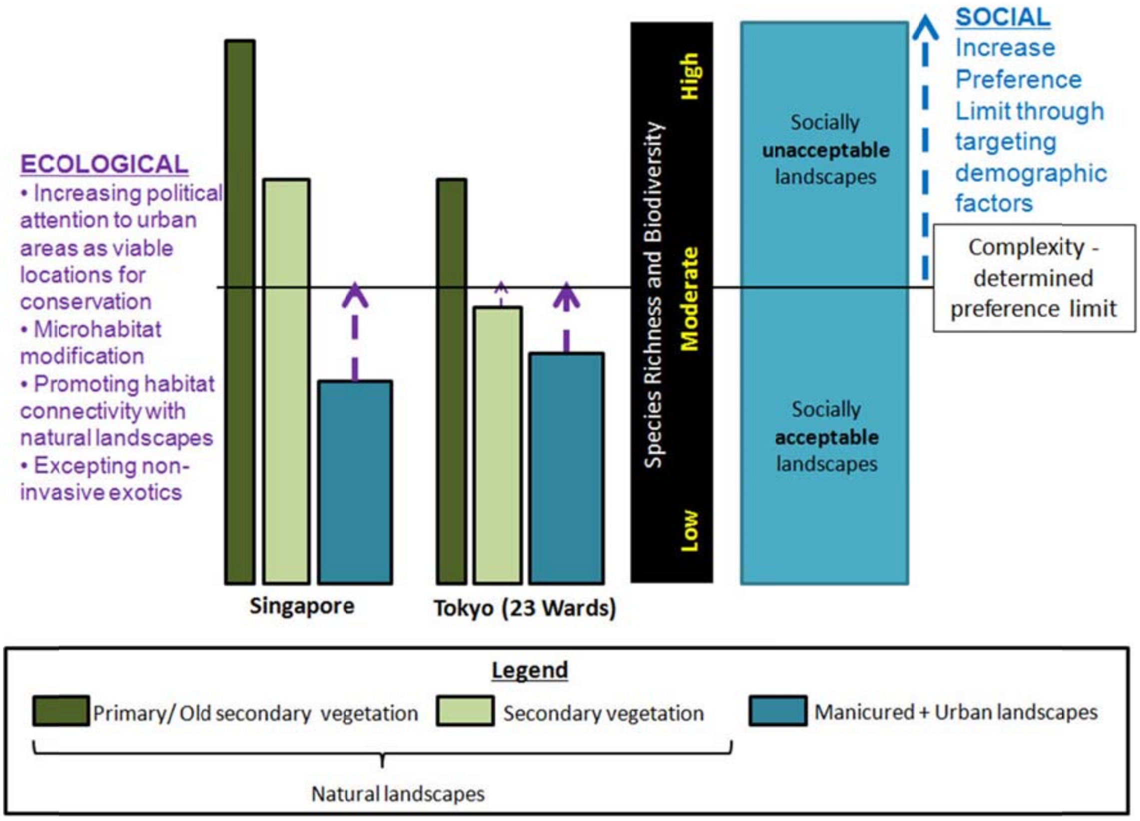


Figure 18: Conceptual diagram showing the relation between complexity determined-preference limits and the recommendations which could potentially result in its increase to include naturalistic landscapes in Singapore and Tokyo (23 Wards).

6.1 Social recommendation

6.1.1 Targeting social factors correlated with increased acceptance of naturalistic landscapes

This thesis presents policy-targetable factors which were shown to be correlated with preference for naturalistic landscapes, especially in Singapore and Tokyo (23 Wards) in Section 4.2.1 of this thesis. Specifically these factors are increasing conservation education in Singapore (Stepwise Forward MLR, df=12, $p < 0.05$) and encouraging frequent park-going behavior in Tokyo (23 Wards) (Stepwise Forward

MLR, df=9, $p < 0.05$). Targeting these factors could also serve to increase the complexity determined-preference limit of an average urban resident in these two cities to include more naturalistic landscapes, based on scientific and experiential understanding.

However, it is also useful to note that positive feedback loops exist between pro-nature attitudes, experience in nature and preference of natural landscapes (Section 4.2.1). In the case of Singapore and Tokyo (23 Wards), promotion of any point within the loop could result in a positive cascade effect towards appreciation of biodiversity associated with natural landscapes. In Singapore, this positive feedback loop exists between conservation education, spending time in natural landscapes abroad, younger age, desire against altering nature for human comfort and natural landscape preference. In Tokyo (23 Wards) this loop was found to exist between frequent visits to manicured parks, younger age, pro-conservation behaviour for nature's sake and natural landscape preference.

6.2. Ecological recommendations

6.2.1 Disseminating a new optimism for urban biodiversity conservation

As mentioned in chapter 3 and chapter 5, there is unrealized potential in urban areas for biodiversity conservation of red-list species and possibly, a larger number of native biodiversity by association. This is especially in the case of Vancouver and to a certain extent in Tokyo (23 Wards), where biodiversity conservation falls into the default social acceptance of landscape types. As such, it is pertinent to encourage a mindset change among policy-makers and conservation practitioners that urban areas are just a fallback option for biodiversity conservation. Cities should also be “rebranded” as unique ecosystems in order to direct future political, economic and scientific will towards more effective research on urban ecology. In summary, some city-specific recommendations are:

1) **Singapore:** Urban planning in Singapore has deemed the highly diverse and complex natural environment to be at a conflict with efficient city functioning. As such, biodiversity conservation can be done through the restoration of natural environments and improving the ecological quality of manicured landscapes without changing their appearance (i.e. microhabitat modification).
2) **Tokyo (23 Wards):** Draw the attention of people to semi-natural landscapes already present in the city as a result of the local historical context of landscape planning. Since people are already used to secondary landscapes as being part of the urban landscape (see chapter 4 for discussion on social exposure to landscape types in Tokyo), it is an apt reminder of the rich natural potential the city holds.
3) **Vancouver:** Keep the status quo of increasing the amount of green space in the city. Vancouver presents the most optimistic situation where a whole range of landscape types are socially accepted. Natural landscapes with less complexity and diversity, coupled with an urban planning history which has always aimed for human connection with nature, has enabled Vancouver to be a “model city” in terms of urban biodiversity conservation.

However, the view of promoting urban areas as feasible spots for biological conservation has not been fully realized by city planners in areas such as Vancouver and Singapore. For example, a planner at the Metro Vancouver City government board mentioned that "o*ne has to look at biodiversity differently in the urban context because it is greatly reduced.*" Another interviewee added that "*Vancouver wants green corridors but…this works fine in a natural condition but in the urban environment, you would never get the (same) standard*". Along these lines, all interviewees in Singapore also expressed regret that natural environments have been cleared, resulting in "*degraded urban deserts*". National documents in Singapore, Tokyo and Vancouver also feature urban biodiversity conservation as being mixed with broad terms such as "sustainable green cities", while conservation methods are focused on rural methods such as green corridor and reserve creation (National Biodiversity Strategy of Japan 2012 – 2020, Nparks 2009, The biodiversity conservation strategy partnership, Vancouver. 2010; Ministry of National Development, Singapore 2013).

Ironically, it is private companies in each country that are taking up the mandate of having an optimistic outlook on urban biodiversity conservation. Companies involved in the Japan Business for Biodiversity (J-BIS) like Tokyo Tatemono and Mitsui Sumitomo have begun to integrate native plants into the design of their manicured gardens at Otemachi no mori and the rooftop garden at the Surugadai building respectively. In Singapore, a similar approach was taken by WOHA Architecture Company for the terraced rooftop gardens of Park Royal Hotel. Perry and Associates, a landscape design company in Vancouver has also took efforts to conduct environmental impact assessments on their residential developments at Burns Bog, resulting in the integration of native vegetation into the resultant development (Interview, November 2013). However, there is comparatively less focus on micro-habitat modification – a relatively new method which is beginning to show much promise for urban biodiversity conservation.

6.2.2 Microhabitat modification in manicured landscapes

Recent studies on microhabitat modification in parks have shown that small changes, such as varying vegetation structure, can potentially be more effective than large scale methods like increasing park sizes, for biodiversity conservation (Beninde et al., 2015). Previous studies on small urban parks (pocket parks of less than 20,000 square meters) have been done by Shwartz et al. (2013) in Paris. Results show that local scale management practices such as varying garden soil composition and increasing native plant cover helped to improve bird and insect pollinator species richness. In residential parks within Canberra, Australia, the factor which contributed most to increased bird species richness was total green area within 250 meters of the sampled park, irrespective of the connectivity between these areas (Ikin et al. 2013). Gaston et al. (2005), on the other hand, found that provision of wooden blocks with holes and nettle plants increased abundance of solitary aculeates and invertebrate species respectively.

In this study, red-listed species which have shown adaptations to the urban environment and their associated manicured landscapes can potentially benefit from the provision of suitable microhabitat. A study by Benvenuti (2004) has demonstrated that an experimental trail of planting grassland plants in Tuscany was not only successful in adapting native grassland species to urban environments, but successful in increasing pollinator diversity. Furthermore, red-listed species which occurred in urban environments in this study were found to be non-harmful to humans, with the exception of one reptile [King cobra (*Ophiophagushannah*)] in Singapore. Figure 19 shows a hypothetical microhabitat design based on an existing park in Singapore.

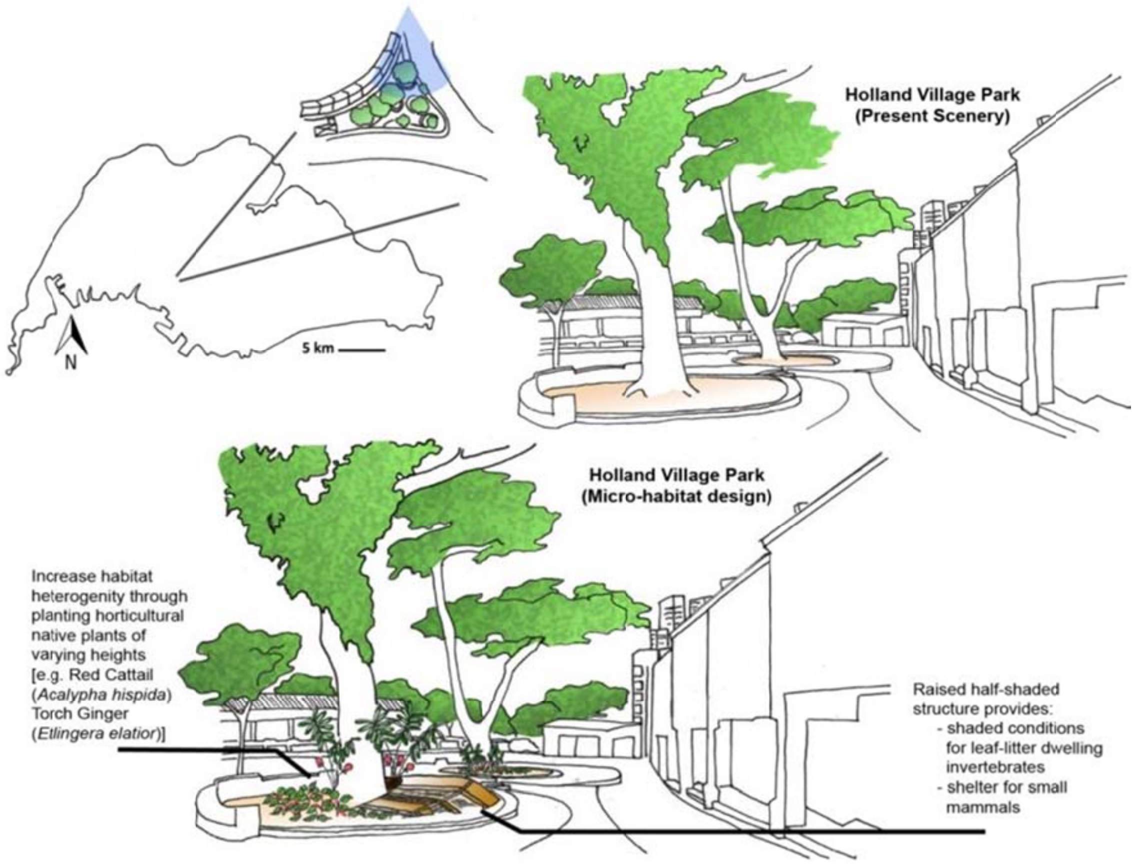


Figure 19: Hypothetical visualization of final project output in a pocket park in Singapore (based on the Holland Village Park, 3000 square meters).

6.2.3 Promotion of habitat connectivity with remaining natural landscapes

Section 3.2 describes the habitat-type irreplaceability values of natural and manicured landscapes. In Tokyo (23 Wards) and Singapore, habitat-type irreplaceability of natural landscapes (especially a combination of primary and secondary vegetation, Table 5) is higher than manicured landscapes and urban areas. This value amounted to a more than three-fold increase over the habitat-type irreplaceability of urban areas in Singapore and a two-fold increase over the conservation potential of urban areas in Tokyo (23 Wards).

As such, effort should be taken to connect manicured parks within the two cities to remnant patches of primary and secondary vegetation, especially when these two natural vegetation types are found adjacent to each other. This type of connectivity should be prioritized over connecting manicured parks together to form green-networks within urban confines.

6.2.4Accepting non-invasive exotics are part of urban nature: Climate change and red-list species conservation

Planning for biodiversity within urban confines is also a matter of planning for adaptation to future changes. Cities ultimately present a different ecosystem from the surrounding natural areas as they contain environmental differences in areas such as temperature and soil composition (Alvey, 2006). There is therefore need to consider urban biodiversity as both red-list species that can adapt to current urban conditions, as well as exotic species that are capable of performing well, and provide microclimatic stabilization in the face of urban stresses (Sæbø et al., 2003). For example, tree cultivars such as Platanus x acerifolia and Acer x freemanii have been hybridized to be more suitable to the higher heat island effect, and dust pollution in urban areas (McKinney, 2002). In turn, these species could function as shade trees, to regulate urban temperatures and provide food in order to help native species to thrive better in cities.

Focusing on the promotion of non-invasive exotic species within urban confines may also bode well for increasing social acceptance of a more biodiverse city. In some cases, non-invasive exotic species such as the Ginko (*Ginko biloba*) tree and the Cinnamon (*Cinnamonium Camphora*) in Tokyo (23 Wards) have long captured the general public's imagination as an urban tree of cultural and aesthetic significance. This tree is often planted en-masse as a roadside shade tree, and also as the icon of the University of Tokyo, a local university which has been held in relative esteem by the Japanese citizens (Figure 20). Should a charismatic species such as the Ginko or Cinnamon tree be used as a focal point for the promotion of biodiversity within urban confines, it may function as an anchor-species which secures urban resident's support of measures which would increase local species-richness.

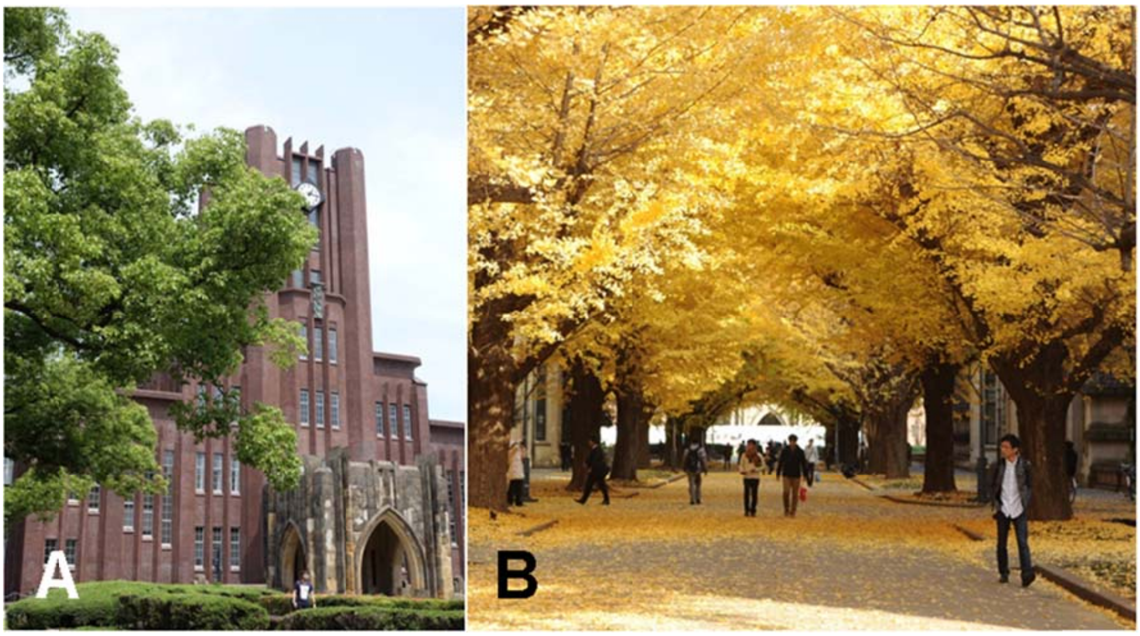


Figure 20: Picture showing non-invasive exotic species which have charismatic value to urbanites: A) A cinnamon tree (*Cinnamonium Camphora*) flanking the iconic Yasuda hall at the University of Tokyo, Hongo campus. B) Ginko trees (*Ginko biloba*) on the walkways of the University of Tokyo, Hongo campus.

There is therefore a possibility that there is need to consider a new conservation "benchmark" with regards to the amount and type of biodiversity that should be potentially conserved in cities. Traditional biological conservation goals have always emphasized the "wilderness ideal", putting forward pristine tracts of nature as the standard that conservation efforts should be held up to (Van Dyke, 2008). However, this section puts forward the fact that non-invasive exotics may be better adapted to stabilize the adverse micro-climates present in urban environments and may function as a focal point to direct social acceptance for wider urban biodiversity conservation. Future urban scenarios may thus include non-invasive exotics within a more fluid baseline for urban biodiversity conservation standards. There might be a case whereby resultant species-richness in cities would increase with the inclusion of a higher number and variety of red-list species in its tow. However, the exact species assembly may differ greatly from the original pristine vegetation within the city's ecological context. This in turn, may not be a negative phenomenon as urbanites would still be exposed to a more biodiverse environment, except that it includes both red-listed and exotic species.

Caution should be expressed, however, over the potential over-reliance on exotic species which may prove better for adaptation to urban conditions. This is because an over-reliance could result in the promotion of biotic homogenization across cities throughout the globe (McKinney, 2006) and is counterproductive to urban biodiversity conservation. In this, red-list species which have shown recent adaptations to urban areas (for example those which have been shortlisted in this study, Appendix B) would serve as a focal point for re-orientating urban biodiversity goals.

Red-list species are a good proxy for native biodiversity and ensuring their presence would therefore ensure that native biodiversity in a city’s given ecological context is well represented. It is also optimistic to note that this study has provided evidence for the occurrence of red-listed species in all three study cities, despite the potentially adverse environmental conditions present in urban areas (Alvey, 2006).

Constant monitoring should also take place in order to ensure that exotic species do not eventually become invasive. These species should also be promoted alongside urban-adapted red-list species and a balance should be established such that the popularization of such species does not lead to a loss of sight on conservation goals.

6.3. Linking social and ecological recommendations

The practical recommendations given in this chapter have been suggested in light of the ecological (chapter 3) and social (chapter 4) uniqueness of each of the study sites. These individual recommendations are not meant to be stand-alone measures but can potentially work together in a positive feedback spiral, ultimately resulting in a more biodiverse urban environment (Figure 21).

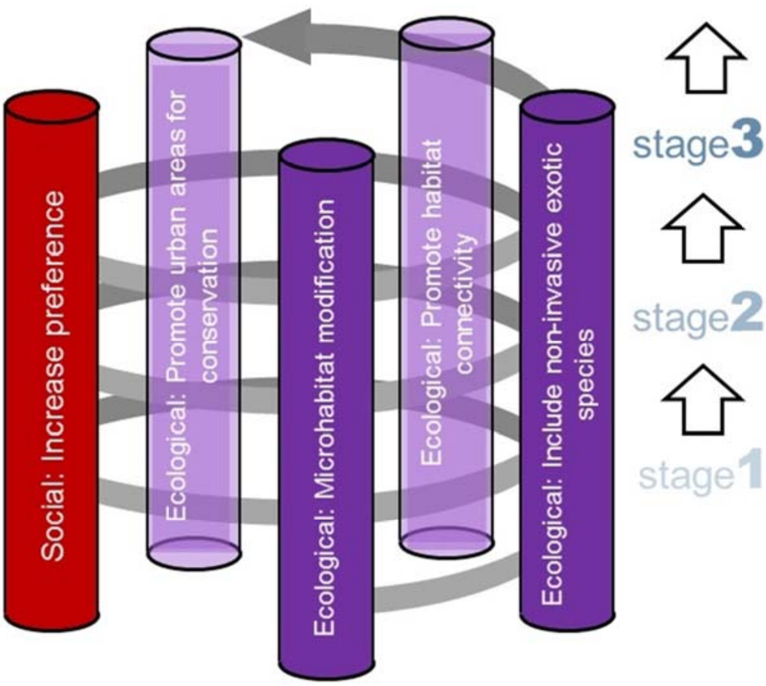


Figure 21: Diagram illustrating a hypothetical positive-feedback loop between social (red) and ecological (purple) recommendations that would result in a more biodiverse city while raising social landscape preference to include more natural elements within urban greens.

One possible positive feedback loop between social and ecological recommendations is outlined below:

- Governments should first recognize the potential for urban areas to conserve a significant amount of red-list species (section 6.2.1). This would result in the proliferation of microhabitat modification practices which increase the ecological conservation potential of manicured landscapes within cities such as Singapore and Tokyo (23 Wards) without changing its scenic aesthetic appearance so as to keep within existing social landscape preference(section 6.2.2).
- Urbanites can be simultaneously connected to the acceptance of a more biodiverse city through the use of charismatic non-invasive exotic species which are better adapted to the urban microclimate. In turn, these species would help to stabilize local microclimates within urban areas for the establishment of a higher number of red-list species (section 6.2.4).
- This in turn, would enable urbanites to have a more positive experience within urban green-spaces. Ecological measures should also be done in conjunction with public education. Collectively, these factors influence landscape preference to slowly be more accepting of natural environments (section 6.1.1).
- Lastly, should social preference ultimately include natural landscapes, parks could either be naturalized further, or connected with ease to existing natural landscapes (section 6.2.3).

This positive feedback loop can also be discussed in terms of an implementation timescale, when put into perspective with the theoretical framework of the "complexity determined preference limit". Figure 22 and 23 outline the present social and ecological situations in Singapore and Tokyo (23 Wards) with respect to the landscape types (and inherent red-list species richness) that are currently accepted within each respective city. It also displays possibilities of how the complexity preference limit, the area allocated to each landscape type (represented by the thickness of the landscape bars), and the amount of biodiversity potentially harbored within each landscape type (represented by the height of the landscape bars) would change according to hypothetical scenarios where recommendations are either not applied (Figure 22) or applied (Figure 23). The thickness of the landscape bars (representing area allocated to each landscape type within Singapore and Tokyo (23 Wards) are obtained from the land-use maps in Figures 3 and 4 [Singapore: Yee et al., 2011; Tokyo (23 Wards): Ministry of Environment, Tokyo, 2003; Vancouver: Simon Fraser University, 2006].

An acceptable timescale within which to expect noticeable ecological and social change could be placed at about 60 years. This is sufficient time for about fourto five generations of red-list mammals to affect a significant population increase (or decrease). With respect to other red-list taxa, this time-frame may either be extended (in the case of vascular plants) or shortened (in the case of shorter-lived taxa such as amphibians or birds).

In the case whereby recommendations are not applied, population densities of Singapore and Tokyo (23 Wards) continue to increase due to rapid urbanization and for the latter, increased rural-urban migration. Urban biodiversity conservation measures are maintained as the predominant increase of manicured landscapes within the urban fabric. In this case, the area allocated for natural landscapes in both cities may decrease drastically, while area allocated to manicured landscapes may increase. However, species-richness across all landscape types may start to decline in lieu of urbanization and non-contextualized conservation schemes. As there are no measures put in place to increase social acceptance of biodiversity within manicured landscapes, the complexity preference limit also stays unchanged (Figure 22).

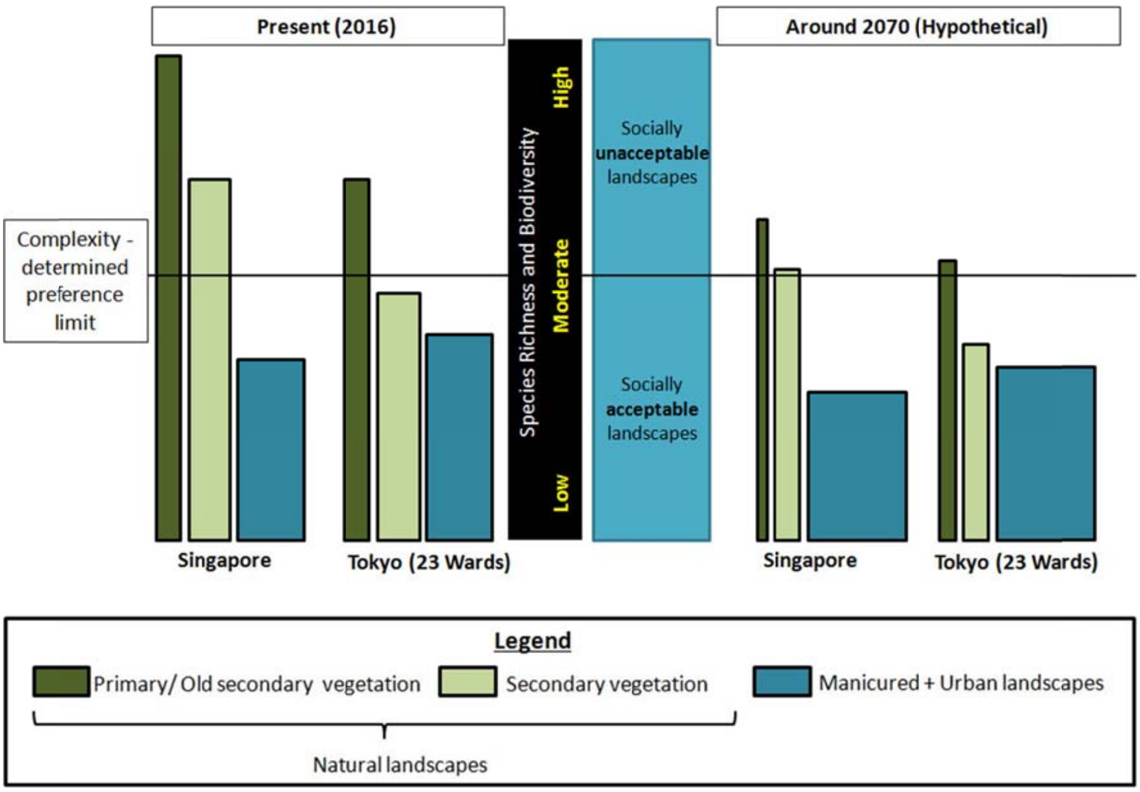


Figure 22: Diagram showing land use and land type change, along with the placement of the complexity determined preference limit and landscape-level species richness in a hypothetical future scenario where recommendations are not applied.

Should recommendations be applied in totality, under the assumption that there would be a positive reinforcement between both social and ecological means for increasing urban biodiversity, there could be a "best case scenario" whereby there is an increase in the diversity of manicured landscapes and manicured and secondary landscapes in Singapore and Tokyo (23 Wards) respectively. Unfortunately, the area of natural landscapes in these two cities is realistically likely to keep decreasing, in light of a trend of increasing urbanization (United Nations, 2005). Species-richness in natural landscapes is also expected to decline with increasing fragmentation and decreasing patch sizes. However, with proper application of microhabitat modification and non-invasive exotic species within urban parks, species-richness of manicured landscapes may start to increase. Increased diversity and connectivity between manicured landscapes and the surrounding fragmented natural landscapes may then result in a slowing-down of the decline of species-richness in natural landscapes due to urbanization effects. Simultaneous with the increase in urban biodiversity as affected by the ecological recommendations, it is expected that urbanites would acclimatize to their newer, more biodiverse surroundings. This would ultimately result in the raising of the complexity determined preference limit to also include more natural landscapes [e.g. primary vegetation in Tokyo (23 Wards) and perhaps, secondary vegetation in Singapore]. A diagrammatic representation of this future hypothetical scenario can be found in Figure 23.

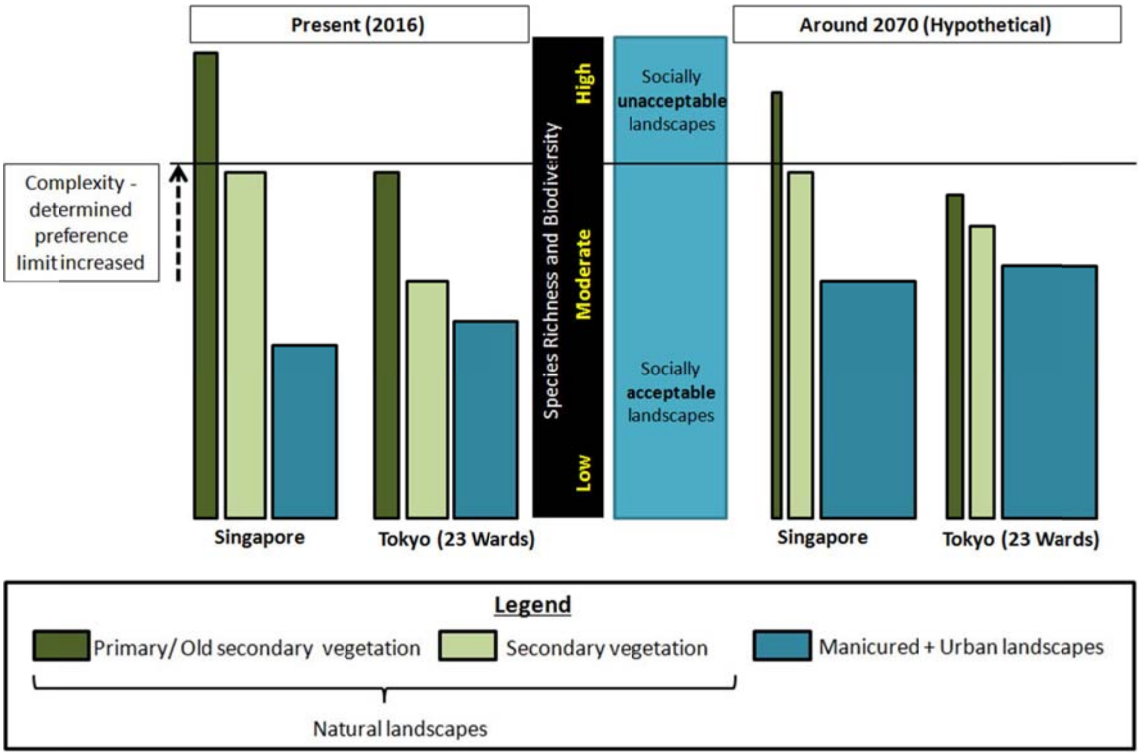


Figure 23: Diagram showing land use and land type change, along with the placement of the complexity determined preference limit and landscape-level species richness in a hypothetical future scenario where recommendations are applied.

7. CONCLUSION

This thesis discusses the need and means to contextualize urban biodiversity conservation in cities within different ecological zones (Chapter 1). This is achieved through a global perspective of discussing integrated measurements of social and ecological indicators with use of study sites in Singapore (tropical), Tokyo (23 Wards) (warm temperate) and Vancouver (cold temperate) (Chapter 2). These three cities were found to be ecologically unique in terms of total red-list species richness, and habitat-type irreplaceability of urban and manicured green-spaces (Chapter 3). Furthermore, it was found that scenic aesthetics was a bigger driver of landscape preference than nature conservation intent in cities such as Singapore and Tokyo (23 Wards) where natural landscapes are more biodiverse and visually chaotic as compared to their cool temperate counterparts in Vancouver (Chapter 4).

From results obtained in Chapters 3 and 4,this thesis establishes the theoretical link between each of the measurement indicators to come up with the "complexity-determined preference limit" for natural and manicured landscapes in different ecological zones (Chapter 5). This limit is tied primarily to landscape perception as primarily driven by scenic aesthetics. It is also tied to the amount of species-richness inherent in a given landscape where higher species-richness is correlated with a more chaotic landscape and the probability of encountering unpleasant biodiversity. Lastly, the thesis discusses practical ways in which the ecological quality of landscapes below the complexity-determined preference limit (i.e. socially accepted landscapes) can be increased within this boundary. It also discusses how the complexity determined preference limit can be raised through targeting demographic factors such as conservation education and experience (Chapter 6).

The following paragraphs of this conclusion segment provide a brief recap of the contents in each thesis chapter:

Chapter 1: In the history of biological conservation and ecological landscape planning, humans and the natural environment have been kept geographically separate at a fundamental level. Tied closely into the concept of land-use zoning and the creation of nature reserves (Leitão & Ahern, 2002; Van Dyke, 2008), biodiversity conservation was seen as something which should take place only in pristine habitats. However, it has been recently recognized that urban areas are needed as a complimentary means for conservation. This is due to recent recognition of cities as being able to harbor a significant amount of biodiversity which increases the resilience of existing urban greens. However, current urban biodiversity conservation methods have originated from developed countries in the global North and are widely spread throughout the world. As such, there is a need for contextualization of these measures in accordance to a city's unique ecological and social profile.

Chapters 1 and 2: To date, much research on the ecological component of urban biodiversity conservation is focused on single-taxa studies on general rural-urban species gradient or finding diversity correlates with other taxa. There is need for more studies focusing on quantifying habitat-type irreplaceability with a specific focus on red-list species-richness from multiple taxa. The ecological component of urban biodiversity conservation has not been well integrated with the social landscape perception indicators, which are important in determining the degree by which landscapes are naturalized in cities. Furthermore, there has been contrasting evidence that both nature conservation intent and scenic aesthetic appreciation are potential effectors of landscape preference. In light of these ecological and social academic gaps, this thesis addresses the contextualization of green-space creation and red-list species conservation through consideration of the inter-relationships between the ecological and social factors of (1) habitat-type irreplaceability of red-list species and (2) landscape-level nature conservation intent and scenic aesthetic landscape preference (collectively termed as landscape perception) of urban dwellers. Cities chosen for analysis are three highly urbanized centers (population densities of more than 5,200 people per km^2): Singapore, Tokyo (23 Wards) and Vancouver. Although situated in different ecological zones [Singapore: Tropical, Tokyo (23 Wards): Warm Temperate; Vancouver: Cold Temperate]. To date, the three cities have adopted similar strategies for urban red-list species conservation which originate from the global North.

Chapter 3: This chapter aims to put forward the main point that Singapore, Tokyo (23 Wards) and Vancouver are ecologically unique with respect to the total number of red-list species and habitat-specific red-list species richness. Habitat-type irreplaceability values show that naturalistic landscapes (primary/ old secondary and secondary vegetation) have a higher conservation potential in the order of Singapore, Tokyo and Vancouver. Conversely, the conservation potential of urban and manicured landscapes increases in the reverse order. However, urban areas should not be overlooked in terms of their conservation potential as they are able to at least 100 red-list species irrespective of ecological zone.

Chapter 4: This chapter shows the complex relationship that urbanites in Singapore, Tokyo (23 Wards) and Vancouver have with nature at the levels of attitude (natural conservation intent), actual behaviour (scenic aesthetic landscape selection). It also aims to answer the dilemma inherent between nature conservation intent and scenic landscape perception as drivers for landscape preference. In all three study sites, respondents had a significantly higher nature conservation intent as compared to the intent to utilize nature. However, preferred landscapes did not totally match nature conservation intent. Selection of preferred landscapes only coincided with landscapes with the highest habitat-type irreplaceability values in Vancouver. Tokyoites' and Singaporeans' preferences were less consistent and inconsistent with habitat-types best suited for conservation [Tokyo (23 Wards): secondary and manicured landscapes; Singapore: manicured landscapes].Reasons driving landscape selection were given to be predominantly aesthetic for manicured landscapes (a mainstay in landscape preference results) in all three cities, with the exception of Vancouverites citing biodiversity conservation as an additional motivator in the case of natural landscapes (primary and secondary vegetation).Potential daily exposure to natural and manicured landscapes at a neighbourhood level was not a significant factor in influencing respondent's landscape perception.

Chapter 5: In summary, the results of this study (Chapters 3 and 4) support city-specific social and ecological uniqueness. It was found that due to the existence of a "complexity determined preference limit", even when people had the intention to conserve nature and ample opportunity to visit natural landscapes for enjoyment, they would not do so if the landscape had a visual appearance which was beyond this "complexity determined preference limit". This is very evident in the order of Singapore, followed by Tokyo (23 Wards) and lastly, Vancouver. Landscape-level species-richness is closely tied to the complexity preference limit as the higher the species-richness of a landscape, the higher the visual complexity (and the lower the scenic aesthetic) of the landscape. High species-richness in a landscape would also increase the chance whereby a visitor could encounter unpleasant biodiversity within the landscape. The "complexity preference limit" is also shaped by the urban planning histories of each study site. Singaporeans might have been more attuned to manicured landscapes in their immediate vicinity due to a history of purposeful manicuring, while Tokyoites and Vancouverites had an urban history which allowed for more natural environments in their midst (passively in the former but pro-actively in the latter).

Chapter 6: Maximization of biodiversity conservation potential within urban areas is essential to allows for adequate niche-level redundancy to maintain or boost the benefits that urban-green spaces provide to humans (regulatory, cultural and to a certain-extent, provisioning ecosystem services). Furthermore, an increase in biodiversity within a city's ecological context could serve to re-connect humans to nature within their comfort zones. Taking social and ecological constraints, as well as the "complexity-driven preference limit" of each study site, practical recommendations given to increase the conservation potential of urban areas (Section 6) were to:

1) Encourage a mindset that urban areas are just a fallback option for biodiversity conservation to direct future political, economic and scientific will towards more effective research on urban ecology,

2) Utilize micro-habitat modification to increase conservation capacity of manicured landscapes within the "complexity-driven landscape preference limit" especially in Singapore and Tokyo (23 Wards),

3) Maintain existing urban landscape aesthetics while increasing conservation capacity through micro-habitat modification, in order to further improve urban red-list species conservation in Vancouver, and prompt bigger improvements in Singapore and Tokyo (23 Wards).

4) Consider the inclusion of non-invasive exotic species in non-complex landscapes insofar as they aid in the stabilization of microclimates. In some cases, non-invasive exotic species are already widely accepted by the general public [(e.g. Ginko trees in Tokyo 23 Wards)] and can be used as a focal point to increase acceptance of a more biodiversity city.

5) Promote habitat-connectivity between urban parks and adjacent patches of primary and secondary vegetation. This is better for increasing the conservation potential of cities than creating an inter-network of parks consisting only of manicured landscapes.

6) Encourage the following demographic traits for an increased preference for natural landscapes and a higher nature preservation score: **(Singapore)**: conservation education, spending time in natural landscapes abroad, younger age, desire against altering nature for human comfort and natural landscape preference. **(Tokyo, 23 Wards)**: frequent visits to manicured parks, younger age, pro-conservation behavior for nature's sake and natural landscape preference.

Recommendations should also be targeted simultaneously in order to form a positive feedback loop for the promotion of biodiverse urban areas which are socially relevant to urban dwellers' landscape preference.

8. REFERENCES

Alvey, A.A. 2006. Promoting and preserving biodiversity in the urban forest. Urban Forestry and Urban Greening 5: 195-201.

Araújo, M.B. 2003. The coincidence of people and biodiversity in Europe. Global Ecology and Bioregions 12 (1): 5-12.

Balmford A, Moore JL, Brooks T, Burgess N, Hansen LA, Williams P, Rahbek C (2001) Conservation conflicts across Africa. Science 291: 2616-2619.

Bamberg, S. and Moser G. 2007/ Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behavior. Journal of Environmental Psychology 27: 14-25.

BC Species and Ecosystem Explorer. 2013. Ministry of the Environment, British Colubmia, Canada. Accessed at: http://www.env.gov.bc.ca/atrisk/toolintro.html. Accessed on: 3 January 2014.

Biodiversity Strategy Office, Ministry of Environment, Tokyo. 2009. Fourth National Report to the United Nations Convention on Biological Diversity.

Berg, Å and Tjernberg, M. 1996. Common and rare Swedish vertebrates – distribution and habitat preferences. Biodiversity and Conservation 5: 101-128.

Beninde, J., Veith, M., Hochkirch A. 2015. Biodiversity in cities needs space: A meta-analysis of factors determining intra-urban biodiversity variation. Ecology Letters 18: 581-592.

Benvenuti, S. 2014. Wildflower green roofs for urban landscaping, ecological sustainability and biodiversity. Landscape and Urban Planning 124: 151-161.

Biodiversity Strategy Office, Ministry of Environment, Tokyo. 2009. Fourth National Report to the United Nations Convention on Biological Diversity.

Blair, R.B. and Launer, A.E. 1997. Butterfly diversity and human land use: Species assemblages along an urban gradient. Biological Conservation 80: 113–125.

Blair, R.B. 1999. Birds and butterflies along an urban gradient: surrogate taxa for assessing biodiversity? Ecological Applications9: 164–170.

Blair, R.B. 2001. Birds and butterflies along urban gradients in two ecoregions of the U.S. In: Lockwood, J.L., McKinney, M.L.(eds.) Biotic Homogenization. Norwell (MA): Kluwer.

Blair, R.B., Launer, A.E. 1997. Butterfly diversity and human land use: Species assemblages along an urban gradient. Biological Conservation 80: 113–125.

Bonnes, M., Passafaro, P., Carrus, G. 2011. The ambivalence of attitudes toward urban green areas: Between proenvironmental worldviews and daily residential experience. Environment and Behaviour 43(2): 207-232.

Bourassa, S.C. 1991. The aesthetics of landscape. London: Belhaven Press.

Briffet, C. 1991. Proposals for the conservation of nature in urban Singapore. Environmental Monitoring and Assessment19: 275-286.

Bruni, C.M. & Schultz, P.W. 2010. Implicit beliefs about self and nature: Evidence from an IAT game. Journal of Environmental Psychology 30: 95-102.

Bryant, M.M. 2006. Urban landscape conservation and the role of ecological greenways at local and metropolitan scales. Landscape and Urban Planning 76(1-4): 23-44.

Burgess, J., Harrison, C. M., Limb, M. 1988. People, parks and the urban green: A study of popular meanings and values for open spaces in the city. Urban Studies 25, 455-473.

Buttel, F.H. and Flinn, W.L. 1974. The structure of support for the environmental movement, 1968-1970. Rural Sociology 39 (1): 56-69.

Caro, T.M., Pelkey, N., Grigione, M. 1994. Effects of conservation biology education on attitudes towards nature. Conservation Biology 8(3): 846-852.

Caula, S., Hvenegaard, G.T., Marty, P. 2009. The influence of bird information, attitudes, and demographics on public preferences to- ward urban green spaces: The case of Montpellier, France. Urban Forestry and Urban Greening 8: 117–128.

Cass, N. and Walker, G. 2009. Emotion and rationality: the characterization and evaluation of opposition to renewable energy projects. Emotion, Space and Society 2 (1): 62-69.

Chiesura, A. 2004. The role of urban parks for the sustainablecity. Landscape and Urban Planning 68:129-138.

Chong, K.Y., Yee, A.T.K., Yeo, C.K. 2010. Biodiversity: Linking Singapore's fragmented habitats. Nature correspondence 465: 289.

Choo, E. 2011. Greening Singapore's Urban Landscape. Channel News Asia. 15th September, 2011.

Chua, S., Giam, X., Yeo, C.K., Tan, H.T.W. 2008. Attitudes towards biological conservation of one class of National University of Singapore undergraduate students. Nature in Singapore1:9-20.

Chua, M.A.H., Lim, K.K.P., Low., C.H.S 2012. The diversity and status of the civets (Viverridae) of Singapore. Small Carnivore Conservation 47: 1-10.

Cilliers, S.S., Müller, N., Drewes, E. 2004. Overview on urban nature conservation: situation in the western-grassland biome of South Africa. Urban Forestry & Urban Greening 3(1): 49-62.

Clayton, S. 2003. Environmental identity: A conceptual and an operational definition. In S. Clayton, & S. Opotow (Eds.)Identity and the natural environment: The psychological significance of nature. MIT press.

Clergeau, P., Savard, J.P., Mennechez, G., Falardeau, G. 1998. Bird abundance and diversity along an urban-rural gradient: A comparative study between two cities on different continents. The Condor 100: 413 – 425.

Corlett, R. T. 1988. Bukit Timah: The History and Significance of a Small Rain-forest Reserve.Environmental Conservation 15(1) : 37-44.

Corlett, R.T. 1992. The ecological transformation of Singapore, 1819-1990. Journal of Biogeography19: 411-420.

Corlett, R.T. 1997. The Vegetation in the Nature Reserves in Singapore. The Gardens' Bulletin Singapore49: 147–159.

Colding, J., Elmqvist, T., Lundberg, J., Ahrne´ , K., Andersson, E., Barthel, S., Borgstro¨ m, S., Duit, A., Ernstsson, H., Tengo¨ , M., 2003. The Stockholm Urban Assessment (SUA- Sweden). Millennium Ecosystem Assessment Sub-Global Summary Report, Stockholm.

Cornelis, J. & Hermy, M. 2004. Biodiversity relationships in urban and suburban parks in Flanders. Landscape and Urban Planning69: 385-401.

Credit Valley Conservation. 2013. Native Prairie and Meadow Gardens and Landscapes. http://www.creditvalley.ca/wp-content/uploads/2013/05/12-205-prairiemeadow-booklet-web.pdf. Accessed 20 August 2014.

Daily, G. 1997. Nature's services. Island Press, Washington, D.C., USA.

Davidson, G.W.H., Ng, P.K.L., Ho, H.C. (eds.) 2008. The Singapore red data book: Threatened plants and animals of Singapore. Nature Society (Singapore).

Dearborn, D.C. and Kark, S. 2010. Motivations for conserving urban biodiversity. Conservation Biology24(2): 432-440.

Dietz, T., Kalof, L., Stern, P.C. 2002. Gender, values and environmentalism. Social Science Quarterly 83 (1): 353-364.

Duelli, P. and Orbist, M.K. 1998. In search of the best correlates for local organismal biodiversity in cultivated areas. Biodiversity Conservation 7: 297-309.

Dupont WD, Plummer WD. 1990. Power and Sample Size Calculations: A Review and Computer Program, Controlled Clinical Trials 11:116-28.

Eurostat. 2011. Degree of urbanization classification – 2011 revision. http://ec.europa.eu/eurostat/statistics-explained/index.php/Degree_of_urbanisation_classification_-_2011_revision. Accessed on 4 August 2015.

FAO (Food and Agriculture Organization of the United Nations). 2007. Global forest resources assessment findings. Accessed online at: http://www.fao.org/forestry/fra/86627/3n. Accessed on 20 August 2014.

Fernandez-Juricic, E., Jokimäki, J. 2001. A habitat island approach to conserving birds in urban landscapes: case studies from southern and northern Europe. Biology Conservation 10:2023–2043.

Fischer, A., Young, J.C., 2007. Understanding mental constructs of biodiversity: Implications for biodiversity management and conservation. Biological Conservation 136: 271-282.

Forbes, S., Cooper, D., Kendle, A.D., 1997. The history and development of ecological landscape styles. In: Kendle, A.D., Forbes, S.J. (Eds.)Urban Nature Conservation: Landscape Management in the Urban Countryside. E & FN Spon, London.

Frantz, C., Mayer, F.S., Norton, C., Rock, M. 2005. There is no "I" in nature: The influence of self-awareness on connectedness to nature. Journal of Environmental Psychology 25: 427-436.

Fukutake, T. 1967. Japanese Rural Society. Ithaca: Cornell University Press.

Fujii, M, Yokohari M, Watanabe T (2002) Identification of thedistribution pattern of farmlands in Edo (in Japanese withEnglish abstract). City Plan Rev Spec Issue 37:931–936

Garden, J., McAlpine, C., Peterson, A., Jones, D., Possingham, H. 2006. Review of the ecology of Australian urban fauna: A focus on spatially explicit processes. Austral Ecology 31(2): 126-148.

Gaston, K.J. and Blackburn T.M. 1996. The spatial distribution of threatened species: Macro-scales and New World birds. Proceedings of the Royal Society of London 263: 235-240.

Gaston, K.J, Smith, R.M., Thompson, K., Warren, P.H. 2005. Urban domestic gardens (II): Experimental tests of methods for increasing biodiversity. Biodiversity and Conservation 14 (2): 395-413.

Gobster, P. H. 1999. An ecological aesthetic for forest landscape management. Landscape Journal, 18(1): 54-64.

Gordon, A. 2003. A Modern History of Japan from Tokugawa Times to the Present. Oxford University Press, 2003.

Guha, R. 2000. Environmentalism: A global history. Longman, New York.

Grumbine, R. E. 1990. Viable populations, reserve design, and federal lands management: a critique. Conservation Biology 4: 127–134.

Halpenny, E.A. 2010. Pro-environmental behaviours and park visitors: The effect of place attachment. Journal of Environmental Psychology 30: 409-421.

Hanayami, Y. 1988. Japanese agriculture under siege. New York: St. Martin's Press.

Harcourt, M. and Cameron, K. 2007. City making in paradise: Nine decisions that saved Vancouver. Vancouver BC: Douglas & McIntyre.

Henwood, K., & Pidgeon, N. 2001. Talk about woods and trees: Threat of urbanization, stability and biodiversity. Journal of Environmental Psychology 21, 125-147.

Hernandez, J.L., Frankie, G.W., Thorp, R.W. 2009. Ecology of urban bees: a review of current knowledge and directions for future study. Cities and the Environment 2 (1): (art 1) 15 pp.

Herzog, T.R. 1989. A congnitive analysis of preference for urban nature. Journal of environmental Psychology9: 27-43.

Hodgkinson, S., Hero, J.M., Warnken, J. 2007. The efficacy of small-scale conservation efforts, as assessed on Australian golf courses. Biological Conservation 135: 576-586.

Holdgate, M. 1999. The green web: A union for world conservation. International Union for Conservation of Nature and Nature Reserves. Routlege: 2-3.

Hostetler, M., W. Allen, C. Meurk. 2011. Conserving urban biodiversity? Creating green infrastructure is only the first step. Landscape and Urban Planning 100 (4): 369-371.

Hull, R.B. and Stewart, W.P., 1992. Validity of photo-based scenic beauty judgments.Journal of Environmental Psychology 12, 101e114.

Ikin, K., Knight, E., Lindenmayer, D.B., Fischer, J., Manning, A.D. 2013. The influence of native versus exotic streetscape vegetation on the spatial distribution of birds in suburbs and reserves. Diversity and Distributions 19 (3): 194-306.

IUCN (International Union for the Conservation of Nature). 2015. IUCN factsheet: Guiding the conservation of nature for 50 years. https://cmsdata.iucn.org/downloads/iucn_red_list_fact_sheet_web.pdf. Accessed on 30 January 2016.

Ishida, Y. (ed.). 1992. Incomplete city plan of Tokyo (in Japanese).Chikuma-shobo, Tokyo.

J-IBIS (Japan Integrated Biodiversity Information System) (undated) The 4th RDB Species Information Search 2013-2012. http://www.biodic.go.jp/english/rhb/rhb_e.html. Accessed on 20 August 2014.

Leong, H. K. 2000.Citizen participation and policymaking in Singapore: Conditionsand predicaments. Asian Survey 40: 436–455.

Jim, C.Y. & Chen, W.Y. 2006. Perception and attitude of residents towards urban green spaces in Guangzhou (China). Environmental Management 38 (3): 338-349.

Jim C.Y. and Liu H.T. 2001. Species diversity of three major urban forest types in Guangzhou City, China. Forest Ecology and Management 146: 99-114.

Jongman, R.H.G. 1995. Nature conservation planning in Europe: develop- ing ecological networks. Landscape and Urban Planning 32: 169–183.

Kals, E., Schumacher, D., Montada, L. 1999. Emotional affinity toward nature as a motivational basis to protect nature. Environment and Behavior 31 (2): 178-202.

Kaiser, F.G. and Shimoda, T.A. 1999. Responsibility as a predictor of ecological behaviour. Journal of Environmental Psychology 19: 243-253.

Kaplan, R. and Kaplan S. 1989. The experience of nature: A psychological perspective. Cambridge University Press, Cambridge, UK.

Kataoka, S. 2009. Vancouverisem: Actualizing the Livable city paradox. Berkeley Planning Journal 22 (1): 42-57.

Kellert, S.R. 1994. Public attitudes towards bears and their conservation. Bears: Their Biology and Management 9: 43-50.

Khew, Y.T.J, Yokohari, M., Tanaka, T. 2014. Public perception of nature and landscape preference in Singapore. Human Ecology 42: 979-988.

Khew, Y.T.J. and Yokohari, M. (In press). Recommendations for urban biodiversity conservation in the context of landscape preference in Singapore. Cities and the Environment.

Kong, L. & Yeoh, S.A. 1996. Social constructs of urban nature in Singapore. *Southeast Asian Studies* 34 (2): 402-423.

Kühn, I, Brandl, R., Klotz. S. 2004. The flora of German cities is naturally species rich. Evolutionary Ecology Research6**:**749–764.

Küller, R. 1972. A semantic model for describing perceived environment (National Swedish Research Document D12). National Swedish Institute for Building Research, Stockholm.

Kyle, G., Graefe, A., Manning, R, Bacon, J. 2004. Effects of place attachment on users' perceptions of social and environmental conditions in a natural setting. Journal of Environmental Psychology 24: 285-303.

Lawler, J.J., White, B., Master, L.L. 2003 Integrating representation and vulnerability: Two approaches for prioritizing areas for conservation. Ecological Applications 13(6): 1762-1772.

Leitão, A.B. & Ahern, J. 2002. Applying landscape ecological concepts and metrics in sustainable landscape planning. Landscape and Urban Planning59: 65-93.

Master, L.L., Faber-Langendoen, D., Bittman, R., Hammerson, G.A., Heidel, B., Ramsay, L., Snow, K., Teucher, A., Tomaino, A. 2012. NatureServe Conservation Status Assessments: Factors for Evaluating Species and Ecosystem Risk. NatureServe, Arlington, VA

McCleary, R. and Ichtiarani R. 2015. Predation of a non-native changeable lizard (*Calotes versicolor*) by the native Kopstein's bronzeback snake (*Dendrelaphis Kopsteini*) in Singapore. Herpetology Notes 8: 303-304.

McDonald, R. 1984. "Holy Retreat" or "Practical Breathing Spot?": Class perceptions of Vancouver's Stanley Park, 1910-1913. Canadian Historical Review, LXV 2: 127-153.

McHarg, I. 1992. Design with Nature. Wiley & Sons, New York.

McKinney, M.L. 2002. Urbanization, biodiversity and conservation. BioScience 52: 883-890.

McNeely, J.A., Harrison, J., Ingwall, P.D. (eds.). 1994. Protecting nature: regional reviews of protected areas. World Conservation Union, Gland, Switzerland.

Miller, J. and Hobbs, R. 2002. Conservation where people live and work. Conservation Biology 16(2): 330-337.

Melles, S., Glenn, S., Martin, K. 2003. Urban bird diversity and landscape complexity: Species-environment associations along a multiscape habitat gradient. Conservation Ecology 7(1): Article 5.

Mendes, W., Balmer, K., Kaethler, T., Rhoads, A. 2008. Using land inventories to plan for urban agriculture: Experiences from Portland and Vancouver. Journal of the American Planning Association 74: 435-449.

Metro Vancouver SEI (Sensitive Ecosystem Inventory). 2014. Subregional Ecosystems. http://www.metrovancouver.org/planning/development/ecologicalhealth/sei/subregional/Pages/default.aspx. Accessed on 20 August 2014.

Milfont, T.L., and Duckitt, J. 2004. The structure of environmental attitudes: a first and second-order confirmatory factor analysis. Journal of Environmental Psychology 24: 289–303.

Milfont, T.L. and Duckitt, J. 2010. The environmental attitudes inventory: A valid and reliable measure to assess the structure of environmental attitudes. Journal of Environmental Psychology 30: 80–94.

Milfont, T.L. and Gouveia, V.V. 2006. Time perspective and values: an exploratory study of their relations to environmental attitudes. Journal of Environmental Psychology 26, 72–82.

Ministry of the Environment, Tokyo. 東京都環境局（2003）東京現存植生図 CD-ROM の植生凡例を統合して作成. Accessed online: http://www.bird-research.jp/appendix/br01/a01_skylark.html. Accessed 13 May 2014.

Ministry of Internal Affairs and Communication's National Census, Japan. 2011. National Population Census for 2010. http://www.e-stat.go.jp/SG1/estat/NewList.do?tid=000001039448. Accessed on 12 May 2010.

Ministry of National Development, Singapore(2013)From Garden city to City in a Garden. http://www.mnd.gov.sg/MNDAPPImages/About%20Us/From%20Garden%20City%20to%20City%20in%20a%20Garden.pdf. Accessed on 20 August 2014.

Molles Jr., M.C. 2008. Ecology: Concepts and applications 4th Edition. McGrawl-Hill International Edition.

Mori, H. 1998. Land conversion at the urban fringe: A comparative study of Japan, Britain and the Netherlands. Urban Studies 35: 1541-1558.

Myers, N., Mittermeier, R.A., Mittermeier, C.G., da Fonseca, G.A.B., Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403, 853–858.

NatureServe, 2007. IUCN Categories. http://infonatura.natureserve.org/Liucn.htm. Accessed on 30 January 2016.

NatureServe. 2015. NatureServe Conservation Status. http://explorer.natureserve.org/ranking.htm. Accessed on 30 January 2016.

Neilsen, A.B., van den Bosch, M., Maruthaveeran, S., van den Bosch, C.K. 2013. Species richness in urban parks and its drivers: A review of empirical evidence. Urban Ecosystems 17: 305-327.

Newmark, W. D. 1995. Extinction of mammal populations in western North American national parks. Conservation Biology 9: 512–526.

O'Brien, R. M. 2007. A caution regarding rules of thumb for variance inflation factors. Quality& Quantity41: 673-690

Ode, Å, Fry, G., Tveit, M.S., Messager, P., Miller D. 2009. Indicators of perceived naturalness as drivers of landscape preference. Journal of Environmental Management 90 (1): 375-383.

Okutomi, K. 1979. Vegetation of Tokyo and its conservation and management. Department of Environmental Science and Conservation, Tokyo University of Agriculture and Technology. kamome.lib.ynu.ac.jp/dspace/bitstream/10131/3812/11/vegeta_a10.pdf. Accessed on 20 August 2014.

Orians, G.H. and Heerwagen, J.H. 1992. Evolved responses to landscapes. In: Barkow, J.H., Cosmides, L., Tooby, J. (Eds.) The adapted mind: Evolutionary psychology and the generation of culture. Oxford University Press, New York.

Özgüner, H. &Kendle, A.D. 2006. Public attitudes towards naturalistic versus designed landscapes in the city of Sheffield (UK). Landscape and Urban Planning 74: 139-157.

Parsons, R. & Daniel, T.C. 2002. Good looking: in defense of scenic landscape aesthetics. Landscape and Urban Planning 60: 43-56.

Peel, M.C., Finlayson, B.L., McMahon, T.A. 2007. Updated world map of the Köppen-Geiger climate classification. Hydrology and Earth System Sciences 11: 1633-1644.

Perneger, T.V. 1998. What's wrong with Bonferroni adjustments.British Medical Journal 316(7139): 1236–1238.

Poland, T.M. and McCullough, D.G. 2006. Emerald ash borer: invasion of the urban forest and the threat to North America's ash resource. Journal of Forestry 104, 118–124.

Pooley, J.A. and O"Connor, M. 2000. Environmental education and attitudes: emotions and beliefs are what is needed. Environment and Behavior 32(5): 711-723.

Pouta, E., KuuluvainenRekola, M., Tahvonen, O.J., Li., C.Z. 2000. Contingent valuation of the Natura 2000 nature conservation programme in Finland. Forestry73(2): 119-128.

Pyle, R. M. 1978. The extinction of experience. Horticulture 56: 64-67.

Pyle, R. M. 1993. The thunder tree: lessons from an urban wildland.Beacon Press, Boston, Massachusetts, USA.

Reis, E., López-Iborra, G.M., Pinheiro, R.T. 2012. Changes in bird species richness through different levels of urbanization: Implications for biodiversity conservation and garden design in Central Brazil. Landscape and Urban Planning 107(1): 31-42.

Rosenzweig, M.L. 2003. Win-win ecology: how Earth's species can survive in the midst of human enterprise. Oxford University Press.

Sæbø, A., Benedikz, T., Randrup, T.B., 2003. Selection of trees for urban forestry in the Nordic countries. Urban Forestry and Urban Greening 2, 101–114.

Saito, Y. 2007. Everyday Aesthetics. Oxford University Press.

Satterthwaite, D. 1997. Sustainable cities or cities that contribute to sustainable development? Urban Studies 34(10): 1667-1691.

Sauberer, N., Zulka, K.P., Abensperg-Traun, M., Berg, J.M., Bieringer, G., Milasowsky, N., et al. 2003. Surrogate taxa for biodiversity in agricultural landscapes of eastern Austria. Biological Conservation 117: 181-190.

Saunders, D.A., Hobbs, R.J., Margules, C.R. 1991. Biological con- sequences of ecosystem fragmentation: a review. Conservation Bi- ology 5: 18–32

Savage, V., and Kong, L. 1993. Urban constraints, political imperatives: Environmental "design" in Singapore. Landscape and Urban Planning 25: 37-52.

Schroeder, H.W. 2007. Place experience, gestalt, and the human-nature relationship. Journal of Environmental Psychology27: 293-309.

Schultz, W.P. 2000. Empathizing with nature: The effects of perspective taking on concern for environmental issues. Journal of Social Issues56: 391-406

Shwartz, A., Shirley, S., Kark, S. 2008. How do habitat variability and management regime shape the spatial heterogeneity of birds within a large Mediterranean urban park?, Landscape and Urban Planning 84 (3-4): 219-229.

Shwartz, A., Muratet, A., Simon, L., Julliard, R. 2013. Local and management variables outweigh landscape effects in enhancing the diversity of different taxa in a big metropolis. Biolgical Conservation 157: 285– 292.

Shwartz, A., Turbé, A., Julliard, R., Simon, L., Prévot. A.C. 2014. Outstanding challenges for urban conservation research and action. Global Environmental Change 28: 39-49.

Simon Fraser University. 2006. Vancouver land use map. Accessed online at: http://www.sfu.ca/geog/geog355fall06/kyc3/Data%20Acquistion.html. Accessed 24 September 2013.

Soh, E.Y. and Yuen, B. 2006. Government aided participation in planning Singapore. Cities 23 (1): 30-43.

Sorensen, A. 1999. Land readjustment, urban planning and urban sprawl in the Tokyo Metropolitan Area. Urban Studies 36 (13): 2333-2360.

Statistics Canada (2011) StatsCan 2011 Census for Vancouver CMA. http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/hlt-fst/pd-pl/Table-Tableau.cfm?LANG=Eng&T=303&SR=1&S=51&O=A&RPP=9999&PR=0&CMA=933. Accessed 20 March 2015.

Statistics Singapore (2014) Statistics Singapore - Latest data - Population and land area (Mid-year estimates). http://www.singstat.gov.sg/statistics/latest-data#14. Accessed 20 March 2015.

Stewart G.H., Ignatieva, M.E., Meurk, C.D., Richard, D.E. 2004. The re-emergence of indigenous forest in an urban environment, Christchurch, New Zealand. Urban Forestry & Urban Greening 2(3): 149-158.

Tan, M. B. 2009. An open conversation with Minister Mentor: Greening of a Nation. Accessed online at: http://www.nparks.gov.sg/cms/index.php?option=com_news&task=view&id=151&Itemid=50. Access date: 20 January, 2013

Thomas, C.D. and Mallorie, H.C. 1985. Rarity, species richness and conservation: Butterflies of the Altas Mountains in Morocco. Biological Conservation 33: 95-117.

The Biodiversity Conservation Strategy Partnership. 2008. Strategic directions for biodiversity conservation in the Metro Vancouver Region. Georgia Basin Action Plan: 40. www.metrovancouver.org/about/publications/Publications/StrategicDirectionsBiodiversityConservation.pdf. Accessed on 20 August 2014.

Tokyo Statistics Division, Bureau of General Affairs. 2015. 東京都総務局統計部. Accessed at: http://www.toukei.metro.tokyo.jp/. Accessed on: 7 June 2015.

Vaske, J.J. and Kobrin, K.C. 2001. Place attachment and environmentally responsible behavior. The Journal of Enviornmental Education 32 (4): 16-21.

van der Windt, H.J., Swart, J.A.A., Keulartz, J. 2007. Nature and landscape planning: Exploring the dynamics of valuation, the case of the Netherlands. Landscape and Urban Planning 79: 218-228.

Van Dyke, F. 2008. Conservation biology foundations, concepts, applications. Springer Netherlands: 1-27.

van Liere, K.D & Dunlap, R.E. 1980. The social bases of environmental concern: a review of hypotheses, explanations and empirical evidence. Public Opinion Quarterly 44(2): 181-197.

Walsh, R.M. 2013. The origins of Vancouverism: A historical inquiry into the architecture and urban form of Vancouver, British Columbia. Thesis: Doctor of Philosophy (Architecture). University of Michigan.

Wakefield, S.E.L., Elloitt, S.J., Cole, D.C., Eyles, J.D. 2001. Environmental risk and (re)action: Air quality, health and civic involvement in an urban industrial neighborhood. Health and Place 7(3): 163-177.

Wong, P.P. 1969. The surface configuration of Singapore Island: A quantitative description. Journal of Tropical Geography 29: 64-74.

Yang, B. and Kaplan, R. 1990. The perception of landscape style: A cross-cultural comparison. Landscape and Urban Planning 19: 251-262.

Yee, A.T.K., R.T. Corlett, S.C. Liew, H.T.W. Tan. 2011 The vegetation of Singapore – an updated map. Gardens Bulletin Singapore 63 (1&2): 205-212.

Yokohari, M. and Amati, M. 2005. Nature in the city, city in the nature: case studies of the restoration of urban nature in Tokyo, Japan and Toronto, Canada. Landscape and Ecological Engineering 1: 53-59.

Yokohari, M., Amati, M., Bolthouse, J., Kurita, H. 2010. Restoring agricultural landscapes in shrinking cities: Re-inventing traditional concepts in Japanese landscape planning. In: Primdahl, J. and Swaffield, S. (eds.). Globalisation and agricultural landscapes: Change patterns and policy trends in developed countries. Cambridge University Press.

Yokohari, M. and Khew, Y.T.J. (In Press). Landscape design for resilient cities in Asia: Lessons from integrated rural-urban land-use in Japan. In: Sustainable landscape planning in selected urban regions. Springer.

Zagorski, T., Kirkpatrick, J., Stratford, E. 2004. Gardens and the bush: Gardeners' attitudes, garden types and invasives. Australian Geographical Studies 42 (2): 207-220.

Zerbe, S., Maurer, U., Schmitz, S., Sukopp, H. 2002. Biodiversity in Berlin and its potential for nature conservation. Landscape and Urban Planning 944: 1-10.

Zheng, Z.Q. 1995. Street plantings in Guangzhou (in Chinese). Tropical Geography 15: 62-69.

9. APPENDICES

Appendix A: List of Urban Adapted Red-list species

Appendix A.1 Urban adapted red-list species in Singapore

Category	Common name	Scientific name	Status	Habitat*
Mammals	Black bearded tomb bat	*Taphozous melanopogon*	EN	PSMU
	Greater wooly horseshoe bat	*Rhinolophus luctus*	CR	SMU
	Horsfield's flying squirrel	*Lomys horsfieldii*	EN	PSM
	Large Indian civet	*Viverra zibetha*	CR	SMU
	Leopard cat	*Prionailurus bengalensis*	CR	SMU
Reptiles	Dog toothed cat snake	*Boiga cynodon*	EN	PSMU
	Variable reed snake	*Calamaria lumbricoidea*	EN	PSMU
	Common malayan racer	*Coelognathus flavolineatus*	EN	SMU
	Orange bellied ringneck	*Gongylosoma baliodeirum*	EN	PSMU
	Red tailed racer	*Gonyosoma oxycephalum*	EN	PSMU
	King Cobra	*Ophiophagus hannah*	EN	PSM
	Black bearded flying dragon	*Draco melanopogon*	VU	PSM
	Five banded flying dragon	*Draco quinquefasciatus*	EN	PSM
	Tokay	*Gekko gecko*	CR	PSMU
	Large forest gecko	*Gekko smithii*	CR	PSM
Birds	Rudy breasted Cuckoo	*Cacomantis sepulcralis*	CR	PSMU
	Violet Cuckoo	*Chrysococcyx xanthorhynchus*	VU	PSMU
	Blue crowned hanging parrot	*Loriculus galgulus*	EN	PSM
	Spotted Wood Owl	*Strix seloputo*	CR	PSM
	Thick billed pigeon	*Treron curvirostra*	EN	PSM
	Red legged crake	*Rallina fasciata*	VU	PSM
	Greater Painted Snipe	*Rostratula benghalensis*	CR	SMU
	Crested Goshawk	*Accipiter trivirgatus*	CR	PSM
	Black thighed falconet	*Microhierax fringillarius*	CR	SM
	Magpie Robin	*Copsychus saularis*	EN	SMU
	Straw-headed Bulbul	*Pycnonotus zeylanicus*	EN	PSMU
	Grey headed fish eagle	*Ichthyophaga icthyaetus*	CR	SM
	Crested serpent eagle	*Spilornis cheela*	CR	PSM

Vascular Plants	Melindjo	*Genetum gnemon var. gnemon (f)*	CR	SMU
		Genetum gnemon var. gnemon (m)	CR	SMU
		Genetum gnemonoides	CR	SMU
		Genetum latifolium var. funiculare	CR	SMU
		Genetum macrostachyum	CR	SMU
		Genetum microcarpum	CR	SMU
		Desmos dasymaschala	CR	SMU
		Desmos dumosus	CR	SMU
		Polyalthia rumphii	CR	PSM
		Polyalthia sclerophylla	CR	PSM
		Polyalthia sumatrana	CR	PSM
		Polyalthia fusca	CR	PSM
		Polyalthia pisocarpa	CR	PSM
		Polyalthia tomentosa	CR	PSM
		Uvaria lobbiana	CR	SM
		Uvaria hirsuta	CR	SM
		Uvaria lobbiana	CR	SM
		Uvaria pauci-ovulata	CR	SM
		Secamone elliptica	CR	SMU
		Strophanthus caudatus	CR	SMU
		Tabernaemontana corymbosa	CR	SMU
		Tabernaemontana pauciflora	CR	SMU
		Epipremnum pinnatum	CR	PSM
		Pinanga malaiana	CR	PSM
		Cratoxylum cochinchinense	VR	SMU
		Cratoxylum formosum	VR	SMU
		Terminalia bellirica	VR	SMU
		Terminalia phellocarpa	VR	SMU
		Terminalia subspathulata	VR	SMU
		Dioscorea galbra	VR	PSM
		Dioscorea hispida	VR	PSM
		Dioscorea polyclades	VR	PSM
		Dioscorea prainiana	VR	PSM
		Koilodepas longifolium	VR	PSM
		Mallotus penangensis	VR	SM
		Gonocaryum gracile	VR	SM
		Iodes cirrhosa	VR	SM
		Callicarpa longifolia	VR	SM
		Scurrula parasitica	VR	PSM
		Taxillus chinensis	VR	PSM
		Acmena acuminatissima	EN	SMU

	Syzygium acuminatissimum	EN	SMU
	Syzygium cerinum var cerinum	EN	SMU
	Syzygium cerinum var turbinatum	EN	SMU
	Syzygium chloranthum	CR	SMU
	Syzygium cinereum	CR	SMU
	Syzygium claviflorum	CR	SMU
	Syzygium duthieanum	CR	SMU
	Syzygium filiforme var clavimyrtus	EN	SMU
	Syzygium filiforme var filiforme	EN	SMU
	Syzygium glaucum	VU	SMU
	Syzygium inophyllum var bernardii	CR	SMU
	Syzygium inophyllum var inophyllum	CR	SMU
	Syzygium linocieroideum	CR	SMU
	Syzygium maingayi	CR	SMU
	Syzygium muelleri	CR	SMU
	Syzygium namestrinum	EN	SMU
	Syzygium ngadimanianum	EN	SMU
	Syzygium nigricans	EN	SMU
	Syzygium oblatum	CR	SMU
	Syzygium pachyphyllum	CR	SMU
	Syzygium palembanicum	VU	SMU
	Syzygium papillosum	CR	SMU
	Syzygium pauper	EN	SMU
	Syzygium pendens	CR	SMU
	Syzygium polyanthum	VU	SMU
	Syzygium pseudoformosum	CR	SMU
	Syzygium pustulatum	CR	SMU
	Syzygium pycnanthum	CR	SMU
	Syzygium pyrifolium	CR	SMU
	Syzygium ridleyi	EN	SMU
	Syzygium rugosum	CR	SMU
	Syzygium singaporense	CR	SMU
	Syzygium subdecussatum	CR	SMU
	Syzygium syzygioides	VU	SMU
	Tristaniopsis obovata	CR	PSM
	Tristaniopsis whiteana	EN	PSM
	Nepenthes ampullaria	VU	PSM
	Nepenthes raflesiana	VU	PSM

	Barclaya motleyi	CR	PSM
	Erythropalum scandens	VU	PSM
	Lepionurus sylvestris	CR	PSM
	Acriopsis liliifolia	CR	PSM
	Calanthe pulchra	CR	PSM
Pigeon Orchid	*Dendrobium indragiriense*	CR	PSM
Pigeon Orchid	*Dendrobium lobbii*	CR	PSM
Pigeon Orchid	*Dendrobium revolutum*	CR	PSM
Pigeon Orchid	*Dendrobium subulatum*	CR	PSM
	Eulophia graminea	VU	PSM
	Eulophia spectabilis	CR	PSM
	Liparis ferruginea	CR	SMU
	Pteroceras pallidum	CR	SM
	Thrixspermum amplexicaule	CR	SM
	Thrixspermum trichoglottis	CR	SM
	Vanilla griffithii	VU	SM
	Centotheca lappacea	CR	SMU
	Eriachne pallescens	VU	SMU
	Gigantochola ligulata	CR	SMU
	Soejatmia ridleyi	CR	SMU
	Portulaca pilosa spp pilosa	CR	SMU
	Rubus moluccanus L var moluccanus	VU	PSMU
	Uncaria cordata	EN	SMU
	Uncaria lanosa var galbrata	CR	SMU
	Uncaria longiflora var pteropoda	CR	SMU
	Urophyllum blumeanum	CR	SMU
	Urophyllum galbrum	VU	SMU
	Urophyllum griffithianum	EN	SMU
	Urophyllum hirsutum	EN	SMU
	Urophyllum sp 2 of Wong (1989)	CR	SMU
	Urophyllum streptopodium	VU	SMU
	Casearia capitellata	CR	PSM
	Casearia lobbiana	CR	PSM
	Poikilospermum suaveolens	VU	PSMU
	Hornstedtia conica	CR	SMU
	Hornstedtia leonurus	CR	SMU

	Hornstedtia scyphifera var scyphifera	VU	SMU
	Sccaphochlamys tenuis	CR	SMU
	Zingiber griffithii	EN	SMU
	Zingiber puberulum var oboideum	EN	SMU

Appendix A.2 Urban adapted red-list species in Tokyo (23 Wards)

Category	Common name	Scientific name	Status	Habitat*
Mammals	Striped field mouse	*Apodemus agrarius*	CR	PSAMU
	Natterer's bat	*Myotis nattereri bombinus*	EN	PSAMU
	Northern bat	*Eptesicus nilssonii parvus*	EN	SAMU
	Japanese short tailed bat	*Eptesicus japonensis*	EN	SAMU
	Daubenton's bat	*Myotis daubentonii ussuriensis*	VU	PSAMU
	Whiskered bat	*Myotis mystacinus gracilis*	VU	PSAMU
	Ikonnikovi's bat	*Myotis ikonnikovi fujiensis*	VU	PSAMU
		Myotis frater kaguyae	VU	PSAMU
	Asian barbastelle	*Barbasttella leucomelas darjelingensis*	VU	SAMU
		Plecotus auritus sacrimontis	VU	SAMU
	Hilgendorf's tube nosed bat	*Murina leucogaster hilgendorfi*	VU	SAMU
	Ussuri's tube nosed bat	*Murina ussuriensis silvatica*	VU	SAMU
Reptiles	King ratsnake	*Elaphe carinata yonaguniensis*	VU	PSAM
Birds	Oriental stork	*Ciconia boyciana*	CR	PSM
	Branta canadensis leucopareia	*Aletuian Canada Goose*	CR	SAMU
	Buteo buteo oshiroi	*Common Buzzard*	CR	PSAM
	Eurasian Eagle-owl	*Bubo bubo*	CR	PSAM
	Eurasian Scaly Thrush	*Zoothera dauma major*	CR	PSAMU
	Common Buzzard	*Buteo buteo toyoshimai*	EN	SAMU
	Golden Eagle	*Aquila chrysaetos japonica*	EN	AM
	Peregrine Falcon	*Falco peregrinus furuitii*	EN	MU

	Black-winged Stilt	*Himantopus himantopus himantopus*	EN	AM
	Emerald Dove	*Chalcophaps indica yamashinai*	EN	PSAM
	Indian Pitta	*Pitta brachyura nympha*	EN	PSMU
	Winter Wren	*Troglodytes troglodytes mosukei*	EN	PSAMU
	Grey-capped Greenfinch	*Carduelis sinica kittlitzi*	EN	SAMU
	Baikal Teal	*Anas formosa*	VU	AM
		Falco peregrinus japonensis	VU	MU
	Hooded Crane	*Grus monacha*	VU	PSA
	Eurasian Collared-dove	*Streptopelia decaocto decaocto*	VU	SAMU
	Sunda Scops Owl	*Otus lempiji pryeri*	VU	SAMU
	Asian Dollarbird	*Eurystomus orientalis calonyx*	VU	PSAM
	Japanese Robin	*Erithacus akahige tanensis*	VU	PSMU
	Bonin White-eye	*Apalopteron familiare hahasima*	VU	SAM
Amphibians	Tokyo Daruma Pond Frog	*Rana porosa brevipoda*	VU	SAM
Selected Vascular Plants	Variegated scouring rush	*Equisetum variegatum*	CR	MU
		Lindsaea ensifolia	CR	SMU
		Deparia minamitanii	CR	M
	Basket fern	*Drynaria roosii*	CR	PSM
		Goniophlebium amamianum	CR	PSMU
		Persicaria japonica var. taitoinsularis	CR	PSAM
		Chenopodium gracilispicum	CR	SMU
		Aconitum jaluense subsp. jaluense	CR	SM

	Ranunculus ternatus var. lutchuensis	CR	AM
Lesser Meadow-rue	*Thalictrum minus var. chionophyllum*	CR	SAM
	Thalictrum ujiinsulare	CR	SAM
	Cocculus orbiculatus	CR	SAM
	Asarum dilatatum	CR	SM
	Asarum hexalobum var. controversum	CR	PSM
	Asarum minamitanianum	CR	PSM
	Asarum monodoriflorum	CR	PSM
	Hypericum tosaense	CR	SM
ハナナズナ	*Berteroella maximowiczii*	CR	PSAM
Dyer's Woad	*Isatis tinctoria*	CR	AMU
Winter hazel	*Corylopsis gotoana var. pubescens*	CR	MU
ナナツガマママンネングサ	*Sedum drymarioides*	CR	SM
	Hydrangea involucrata var. tokarensis	CR	SAM
	Photinia serratifolia	CR	SMU
	Rubus arcticus	CR	MU
	Rubus nakaii	CR	MU
	Crotalaria calycina	CR	SM
	Crotalaria montana var. angustifolia	CR	PSAMU
	Crotalaria uncinella	CR	PSAMU
	Glycine max subsp. formosana	CR	AM
	Glycine tabacina	CR	SAM
	Indigofera kirilowii	CR	SM
	Uraria picta	CR	SM
	Vigna vexillata var. vexillata	CR	SAM
	Oxalis exilis	CR	SMU
	Geranium shikokianum	CR	M

	var. yoshiianum		
	Linum stelleroides	CR	SM
ヒュウガタイゲキ	*Euphorbia watanabei subsp. minamitanii*	CR	M
コウライタチバナ	*Citrus nippokoreana*	CR	PSM
	Tetradium glabrifolium	CR	PSAMU
	Rhus javanica var. javanica	CR	SM
アンドンマユミ	*Euonymus oligospermus*	CR	PSMU
Korean boxwood	*Buxus sinica var. sinica*	CR	SM
	Vitis romanetii	CR	SAM
	Abelmoschus moschatus var. betulifolius	CR	SAMU
	Elaeagnus epitricha	CR	SMU
	Viola amamiana	CR	SMU
	Viola tashiroi var. tairae	CR	SM
	Angelica minamitanii	CR	MU
オオウバタケニンジン	*Angelica mukabakiensis*	CR	MU
イシヅチボウフウ	*Angelica saxicola*	CR	MU
シナノノダケ	*Angelica sinanomontana*	CR	MU
	Heracleum lanatum subsp. akasimontanum	CR	PSAM
	Moneses uniflora	CR	SM
ムニンツツジ	*Rhododendron boninense*	CR	SM
	Rhododendron dilatatum var. satsumense	CR	SM
	Rhododendron keiskei var. hypoglaucum	CR	M
	Myrsine okabeana	CR	SMU
Primrose	*Primula kisoana var. kisoana*	CR	PSM
Primrose	*Primula macrocarpa*	CR	PSM
	Limonium sinense	CR	M
	Urceola micrantha	CR	PSM
	Cynanchum boudieri	CR	PSM
ヤツガタケムグラ	*Galium triflorum*	CR	SAMU

	Cynoglossum lanceolatum var. formosanum	CR	SAMU
	Hackelia deflexa	CR	SMU
Indian gems	*Amethystea caerulea*	CR	SAMU
センリゴマ	*Rehmannia japonica*	CR	AM
Chinese honeysuckle	*Lonicera japonica var. miyagusukiana*	CR	PSMU
	Lonicera kurobushiensis	CR	PSMU
	Lonicera uzenensis	CR	PSMU
オオベニウツギ	*Weigela florida*	CR	M
シマキンレイカ	*Patrinia triloba var. kozushimensis*	CR	PSAM
	Lobelia zeylanica	CR	PSAMU
Lily	*Lilium alexandrae*	CR	M
Lily	*Lilium callosum var. flaviflorum*	CR	M
Lily	*Lilium nobilissimum*	CR	M
	Rohdea japonica var. latifolia	CR	SM
	Tofieldia coccinea var. kiusiana	CR	SAMU
	Tricyrtis formosana	CR	PSM
	Tricyrtis hitra var. masamunei	CR	PSM

Appendix A.3 Urban adapted red-list species in Vancouver

Category	Common name	Scientific name	Status	Habitat*
Mammals	Pallid bat	*Antrozous pallidus*	EN/ VU	GAMU
	Eastern Red Bat	*Lasiurus borealis*	EN/ VU	SAMU
	Townsend's mole	*Scapanus townsendii*	EN/ VU	SGMU
	Olympic Shrew	*Sorex rohweri*	EN/ VU	PSAGMU
	American badger	*Taxidea taxus*	EN/ VU	SGAM
Reptiles	Desert night snake	*Hypsiglena chlorophaea*	EN/ VU	GMU
Birds	Nelson's Sparrow	*Ammodramus nelsoni*	EN/VU	PSGAM
	Grasshopper Sparrow	*Ammodramus savannarum*	EN/VU	PSGAM
	Burrowing Owl	*Athene cunicularia*	EN/VU	GAMU
	Upland Sandpiper	*Bartramia longicauda*	EN/VU	GAMU
	Canada Goose, *occidentalis* subspecies	*Branta canadensis occidentalis*	EN/VU	SGAMU
	Swainson's Hawk	*Buteo swainsoni*	EN/VU	PSAGMU
	Lark Sparrow	*Chondestes grammacus*	EN/VU	SGAMU
	Horned Lark, *strigata* subspecies	*Eremophila alpestris strigata*	EN/VU	SMU
	Peregrine Falcon, *anatum* subspecies	*Falco peregrinus anatum*	EN/VU	PSAGMU
	Yellow-breasted Chat	*Icteria virens*	EN/VU	SAMU
	Western Screech-Owl, *macfarlanei* subspecies	*Megascops kennicottii macfarlanei*	EN/VU	PSAMU
	Lewis's Woodpecker (Georgia Depression population)	*Melanerpes lewis pop. 1*	EN/VU	PSGAMU
	Black-crowned Night-heron	*Nycticorax nycticorax*	EN/VU	AMU
	Vesper Sparrow, *affinis* subspecies	*Pooecetes gramineus affinis*	EN/VU	GAMU

	Western Bluebird (Georgia Depression population)	*Sialia mexicana pop. 1*	EN/VU	GAMU
	Western Meadowlark (Georgia Depression population)	*Sturnella neglecta pop. 1*	EN/VU	GAMU
Amphibians	Northern Leopard Frog	*Lithobates pipiens*	EN/VU	SGM
Vascular Plants	Carolina meadow-foxtail	*Alopecurus carolinianus*	EN/ VU	SGAMU
	rough fiddleneck	*Amsinckia retrorsa*	EN/ VU	SAMU
	Douglas' sagewort	*Artemisia douglasiana*	EN/ VU	M
	Herriot's sage	*Artemisia herriotii*	EN/ VU	M
	Alaska moonwort	*Botrychium alaskense*	EN/ VU	AMU
	echo moonwort	*Botrychium echo*	EN/ VU	SGMU
	Sprengel's sedge	*Carex sprengelii*	EN/ VU	SMU
	foothill sedge	*Carex tumulicola*	EN/ VU	SGMU
	dark lamb's-quarters	*Chenopodium atrovirens*	EN/ VU	SGAM
	Drummond's thistle	*Cirsium drummondii*	EN/ VU	SGAM
	small-flowered godetia	*Clarkia purpurea ssp. quadrivulnera*	EN/ VU	GMU
	northern tansy mustard	*Descurainia sophioides*	EN/ VU	SMU
	dense spike-primrose	*Epilobium densiflorum*	EN/ VU	GMU
	prairie rocket	*Helianthus nuttallii ssp. rydbergii*	EN/ VU	MU
	Nuttall's sunflower	*Lupinus rivularis*	EN/ VU	SGMU
	streambank lupine	*Marah oregana*	EN/ VU	PSGMU
	coast manroot	*Orthocarpus bracteosus*	EN/ VU	GAMU
	mountain owl-clover	*Piptatherum canadense*	EN/ VU	PSGAMU
	fragrant popcorn flower	*Plagiobothrys figuratus ssp. figuratus*	EN/ VU	PSGAMU

low popcorn flower	*Plagiobothrys humistratus*	EN/ VU	PSGAMU
arrow-leaved rattlesnake-root	*Prenanthes racemosa*	EN/ VU	PSAMU
pale bulrush	*Scirpus pallidus*	EN/ VU	AMU
pink water speedwell	*Veronica catenata*	EN/ VU	GAMU
yellow montane violet	*Viola praemorsa ssp. praemorsa*	EN/ VU	GAMU
California hedge-parsley	*Yabea microcarpa*	EN/ VU	GAMU

Appendix B: Landscape perception questionnaires

Appendix B.1 Singapore

1. Age:

□Under 16 □16 – 18 □ 19 – 25 □ 26 – 30

□ 31 – 40 □ 41 – 50 □51 – 65 □ Over 65

2. Sex:

□ M □ F

3. Nationality

□ Singaporean □ Other (________________)

4. Occupation

□ Student – Primary/ Secondary school □ Student - Secondary school

□ Student - Junior College/ Polytechnic □ Student - University (Degree)

□ Student – University (Postgraduate) □ Working adult (Company employee)

□ Working adult (Civil servant) □ Working adult (Self employed)

□ Working adult (Academia) □ Other (_________________)

5. Have you spent a significant amount of time (two years or more) living in another country? If yes, please write down the name of the country/ countries you have spent two years or more living in.

□ Yes, I have lived in (______________________________) for two or more years

□ No

6. Have you ever taken Ecology/ Conservation related classes or courses in school?

□ Yes

□ No

7. In the past year (please select all that apply):

□ I have taken a walk in the Botanical Gardens or in a park (includes town parks and larger parks such as East Coast Park)

□ I have visited the Zoo/ Bird Park/ Reptile park

□ I have visited one of Singapore's Nature Reserves (e.g. Bukit Timah Nature Reserve)

□ I have attended a talk or lecture on biology/ ecology/ conservation

□ I am/ was a member of a group or organization which engages in activities related to nature/ environment

□ I have NOT engaged in any nature-related activity

9. Which of the following do you think should be included in the term "Nature"? (Please select all that apply)

□ Non-vegetated areas
(e.g. Built/ urban environment)

□ Wilderness areas (e.g. Tropical forest
mangrove forest, freshwater swamp)

□ Managed vegetation
(e.g. Park, roadside vegetation)

□ Scrubland
(e.g. secondary vegetation, abandoned areas)

10. In the next 20 years, which of the following landscapes do you think Singapore should put more efforts into providing land area for? (Please select all that apply)

□ Non-vegetated areas
(e.g. Built/ urban environment)

□ Wilderness areas (e.g. Tropical forest mangrove forest, freshwater swamp)

□ Managed vegetation
(e.g. Park, roadside vegetation)

□ Scrubland
(e.g. secondary vegetation, abandoned areas)

For all the questions in this section, please select one option which best describes your answer to each statement. There are five options ranked from "strongly disagree" to "strongly agree".

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
11.	I do NOT like spending time in wild, untamed areas.	□	□	□	□	□
12.	I like going for trips to wild areas, for example nature reserves.	□	□	□	□	□
13.	Sometimes when I am unhappy, I find comfort in wilderness areas.	□	□	□	□	□
14.	I would rather spend my free time in the city than in wilderness areas.	□	□	□	□	□
15.	Being out in wilderness areas reduces my stress.	□	□	□	□	□
16.	I think spending time in wild areas is boring.	□	□	□	□	□
17.	Industry should be required to use recycled materials/ biodiversity friendly materials even when this costs more than making the same products from conventional raw materials.	□	□	□	□	□
18.	Controls should be place on industry to protect the environment from pollution, even if it means goods will cost more.	□	□	□	□	□
19.	I do NOT think that Singaporeans are going to have to adopt a more conserving lifestyle in the future.	□	□	□	□	□
20.	I would persuade others that environmental protection is important.	□	□	□	□	□

21.	It is wrong for the government to compel industry to put conservation before producing goods in a cost-effective manner.	□	□	□	□	□
22.	I believe that human intervention is needed in order to protect wild areas and its associated biodiversity.	□	□	□	□	□
23.	The worst thing about the loss of Singapore's biodiversity to development is that it may restrict the development of new medicines.	□	□	□	□	□
24.	One of the important reasons to keep water bodies clean is so that people can have a place to enjoy watersports.	□	□	□	□	□
25.	Nature is important because of what it can contribute to the pleasure and welfare of humans.	□	□	□	□	□
26.	I would be willing to donate about SGD 20 a month to fund nature conservation causes.	□	□	□	□	□
27.	An important reason to conserve Singapore's biodiversity is because it is an essential part of Singapore's identity.	□	□	□	□	□
28.	Conservation of a natural area should be integrated with creating recreational areas within that natural area so that it can be enjoyed by people.	□	□	□	□	□
29.	Plants and animals have as much right as humans to exist.	□	□	□	□	□
30.	Nature exists primarily for human use.	□	□	□	□	□

31.	Humans are no more important than any other species.	□	□	□	□	□
32.	Nature in all its forms should be controlled by humans.	□	□	□	□	□
33.	Humans are separate and superior to other forms of nature.	□	□	□	□	□
34.	I prefer a park that is wild and natural to a well groomed and neatly ordered one.	□	□	□	□	□
35.	When nature is uncomfortable and inconvenient, humans have every right to change and remake it to better suit human living.	□	□	□	□	□
36.	Biodiversity such as the long tailed macaque (monkey) which has the potential to harm human beings should NOT be allowed near places where humans live.	□	□	□	□	□
37.	It is alright to install plants which do not biologically originate from regions in Tropical Asia in Singapore as long as they are beautiful.	□	□	□	□	□
38.	I do NOT like to spend time in wild and natural areas because it contains biodiversity which is unpleasant (e.g. mosquitoes, ants).	□	□	□	□	□
39.	When planning green spaces in urban areas, a large part of the design should go into ensuring that the area is biodiversity friendly (i.e. good for biodiversity conservation).	□	□	□	□	□
40.	It makes me sad to see natural environments destroyed.	□	□	□	□	□

41.	I feel a sense of emotional attachment to wild and natural areas.	□	□	□	□	□
42.	I do not believe that protecting the environment is an important issue.	□	□	□	□	□
43.	It upsets me to see animals performing for human entertainment in animal shows as they belong in the wild.	□	□	□	□	□
44.	The idea that nature is valuable for its own sake is wrong.	□	□	□	□	□
45.	It would be detrimental to human emotional well-being if humans are not allowed access to natural areas.	□	□	□	□	□

Additional question (Optional)

46. Do you have any comments or improvements for this survey?

Appendix B.2. Tokyo (23 Wards)

質問１から質問１１は、「自然」に対するあなたのお考えをうかがいます。

　それぞれの質問に対して、あなたの考えに最も近いものひとつにチェック（☑）をつけてください。

		まったくそう思わない	そう思わない	どちらとも言えない	そう思う	とてもそう思う
質問１	国立公園のような自然の多い地域へ旅行したい。	□	□	□	□	□
質問２	休日や自由な時間には、自然のなかよりも街なかで過ごしたい。	□	□	□	□	□
質問３	自然のなかにいるとストレスが発散される。	□	□	□	□	□
質問４	自然が破壊される様子を見ると悲しい気持ちになる。	□	□	□	□	□
質問５	自然保護は重要だ。	□	□	□	□	□
質問６	自然に接する時間がないことは、人間の精神状態にとってよくない。	□	□	□	□	□
質問７	自然は人間が利用するためにある。	□	□	□	□	□
質問８	自然は人間を豊かにすることができる。	□	□	□	□	□
質問９	自然の多い地域でも、レクリエーションのためには、遊具やスポーツのための施設が必要だ。	□	□	□	□	□
質問１０	自然を大切にしたライフスタイルに変えていくべきだ。	□	□	□	□	□
質問１１	自然保護活動のために募金してもいい。	□	□	□	□	□

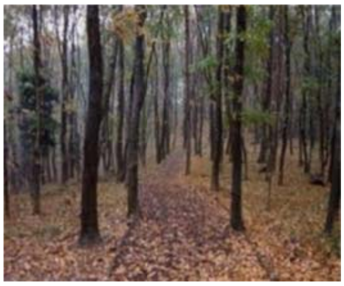
質問１２から質問２２は、「動植物」に対するあなたのお考えをうかがいます。

それぞれの質問に対して、あなたの考えに最も近いものひとつにチェック（☑）をつけてください。

		まったくそう思わない	そう思わない	どちらとも言えない	そう思う	とてもそう思う
質問１２	動物園や水族館で芸をしている動物を見ると、悲しくなる。	□	□	□	□	□
質問１３	動植物も人間と同等の権利を持っている。	□	□	□	□	□
質問１４	人間は、他の動植物の上位に立つ存在だ。	□	□	□	□	□
質問１５	生物多様性の喪失の最大の問題は、それを人間が使う可能性が失われることだ。	□	□	□	□	□
質問１６	日本の生物多様性を保護するのは、それが日本文化にとって重要な要素のひとつだからだ。	□	□	□	□	□
質問１７	人間に害のある可能性のある動植物は、人間の居住地の近くにいるべきではない。	□	□	□	□	□
質問１８	美しい植物であれば、外国産でも日本国内に持ち込んで広めてもよい。	□	□	□	□	□
質問１９	自然のなかにはクモや蚊、ヘビなどの不快な生き物もいるので、近づきたくない。	□	□	□	□	□
質問２０	都市において公園や緑地を設置するときには、生物多様性の保全を考えるべきだ。	□	□	□	□	□
質問２１	生物多様性を維持していくためには、人間が自然に手を加える必要がある。	□	□	□	□	□
質問２２	値段が少々高くても、生物多様性の保全をサポートする商品を買いたい。	□	□	□	□	□

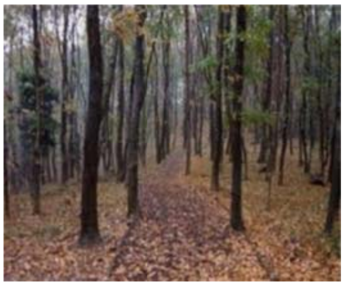
続いて、さまざまな「景観」の写真をご覧いただき、お考えをうかがいます。

質問２３　以下の景観のうち、あなたが「東京の自然」だと思うものすべてにチェック（☑）をつけてください。
また、チェックをつけた景観については、なぜそれが「東京の自然」だと思うか、下のボックスに理由をお書きください。

□　自然林	□　市街地	□　管理された雑木林・人工林
		
理由	理由	理由

□　水田	□　畑地	□　公園
		
理由	理由	理由

質問２４　「2020 年頃の東京」を考えるとき、あなたが「増やすべきだ」と思う景観すべてにチェック（☑）をつけてください。
また、チェックをつけた景観については、なぜその景観を「増やすべきだ」と思うか、下のボックスに理由をお書きください。

□ 自然林	□ 市街地	□ 管理された雑木林・人工林
		
理由	理由	理由

□ 水田	□ 畑地	□ 公園
		
理由	理由	理由

最後に、あなたご自身のことについておたずねします。

質問２５　あなたの性別をお答えください。

□　男性　　□　女性

質問２６　あなたの年齢をお答えください。

□ 16 歳未満　□ 16〜18 歳　□ 19 〜 25 歳
□ 26〜30 歳　□ 31〜40 歳　□ 41 〜 50 歳
□ 51〜64 歳　□ 65 歳以上

質問２７　あなたの国籍をお答えください。

□ 日本　□ その他（　　　　　　　）

質問２８　あなたの職業は次のどれにあたりますか。学生の方は現在のお立場をお選びください。

□ 高校生以下　□ 大学生・大学院生　□ 会社員
□ 公務員　□ 自営業　□ 教育関係
□ その他（　　　　　　）

質問２９　これまでに２年以上、東京２３区以外の場所に居住されたことはありますか？「はい」の場合は、居住されたことのある市町村名をお答えください。
複数ある場合には、直近に居住されていた市町村名をお答えください。

□ はい　（市町村名：　　　　　　　　）　□ いいえ

質問３０　これまでに２年以上、国外に居住されたことがありますか？
「はい」の場合は、居住されたことのある国名をお答えください。
複数ある場合には、直近に居住されていた国名をお答えください。

□ はい　（国名：　　　　　　　　）　□ いいえ

質問３１　これまでに生態学や自然保護に関する講義を受けたり、個人的に勉強されたり、また関連するイベント等に参加されたことがありますか？

□　はい　　□　いいえ

質問３２　自然保護や環境保護に関する団体に現在所属されている、または過去に所属されていましたか？

□　はい　　　　□　いいえ

質問３３　以下のうち、過去１年間に行った活動すべてにチェックをしてください。

- □ 特別な企画や催しのために公園に行った
- □ 日常的に公園に行った
- □ 植物園に行った
- □ 動物園に行った
- □ 国立公園などの自然地域に行った
- □ 農村や山村に行った
- □ その他（）

質問３４　今後の東京の自然のあり方や、この調査に対するご意見がございましたら、
ご自由にお書き下さい。

Appendix B.3. Vancouver

Questions 1 to 11 are related to attitudes and perceptions towards nature. For each of the questions in this section, please select only one option which best describes your answer to each statement.

		Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
Q 1	I like going for trips to wild areas, for example, nature reserves.	□	□	□	□	□
Q 2	I would rather spend my free time in the city than in areas with wilderness.	□	□	□	□	□
Q 3	Being out in wild areas reduces my stress.	□	□	□	□	□
Q 4	It makes me sad to see natural environments destroyed.	□	□	□	□	□
Q 5	Protecting the environment is an important issue.	□	□	□	□	□
Q 6	It would be detrimental to human emotional well-being if humans are not allowed access to natural areas.	□	□	□	□	□
Q 7	Nature exists primarily for human use.	□	□	□	□	□
Q 8	Nature is important because of what it can contribute to the pleasure and welfare of humans.	□	□	□	□	□
Q 9	I would be more inclined to visit a nature reserve if it contains an integrated section for recreational activities (e.g. playground or sports facilities).	□	□	□	□	□
Q 10	Canadian citizens should adopt a lifestyle which is more pro-environmental/ nature conservation.	□	□	□	□	□
Q 11	I am willing to donate money to fund nature conservation causes.	□	□	□	□	□

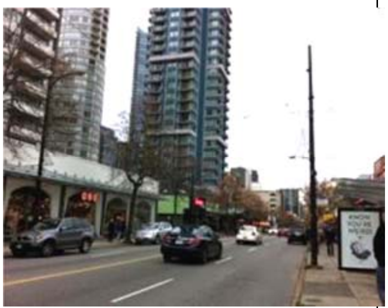
Questions 12 to 22 are related to attitudes and perceptions towards biodiversity. For each question in this section, please select only one option which best describes your answer to each statement.

		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Q 12	It upsets me to see animals being used for human entertainment (e.g. animal shows) as they belong in the wild.	□	□	□	□	□
Q 13	Plants and animals have as much right as humans to exist.	□	□	□	□	□
Q 14	Humans are separate and superior to other species.	□	□	□	□	□
Q 15	The worst thing about the loss of biodiversity is that species which are potentially beneficial to humans may never be discovered.	□	□	□	□	□
Q 16	It is important to conserve Canada's biodiversity because it is an essential part of Canada's uniqueness.	□	□	□	□	□
Q 17	Biodiversity which has the potential to harm humans should not be allowed near places where humans live.	□	□	□	□	□
Q 18	It is alright to install plants which are not native to Canada within Vancouver as long as they are beautiful.	□	□	□	□	□
Q 19	I do not like to spend time in wild areas because it contains unpleasant biodiversity (e.g. mosquitoes, ants, snakes).	□	□	□	□	□
Q 20	Biodiversity friendly/ biodiversity-conservation measures should be considered as a prominent design component for public green spaces in urban areas.	□	□	□	□	□
Q 21	Human intervention is needed in order to protect natural areas and its associated biodiversity.	□	□	□	□	□
Q 22	I would be willing to pay for biodiversity-friendly goods even if they cost more than an equivalent conventionally mass-produced product.	□	□	□	□	□

Section on Landscape preference

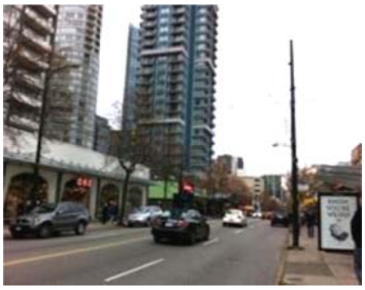
This section contains 2 questions in relation to landscape types. For each question, please <u>select as many options</u> as you feel would represent your response.

Q 23: Which of the following landscapes do you think should be included as “Nature” in Vancouver’s context? *Please select any combination of responses as you deem fit. For the picture(s) that you have selected, please write down the reason for your selection.*

☐ Old Forest	☐ City area	☐ Grassland
		
Reason for selection	Reason for selection	Reason for selection

☐ Agriculture land	☐ Manicured landscape	☐ Secondary vegetation
		
Reason for selection	Reason for selection	Reason for selection

Q 24: By the year 2020, which of the following landscapes do you think Vancouver should allocate more land area for?*Pleaseselect any combination of responses as you deem fit. For the picture(s) that you have selected, please write down the reason for your selection.*

☐ Old Forest	☐ City area	☐ Grassland
		 Giles San Martin, 1 May 2007, CC BY-SA 2.0
Reason for selection	Reason for selection	Reason for selection

☐ Agriculture land	☐ Manicured landscape	☐ Secondary vegetation
		
Reason for selection	Reason for selection	Reason for selection

Respondent's General Information

Q 25: Age

☐ Under 16	☐ 16～18	☐ 19～25
☐26～30	☐ 31～40	☐ 41～50
☐ 51～64	☐ Over 65	

Q 26: Sex

☐ Male ☐ Female

Q 27: Nationality

☐ Canadian ☐ Others （ ）

Q 28: Occupation

☐High school student	☐ Undergraduate/ Graduate student
☐ Private sector employee	☐ Public sector employee
☐ Self-employed	☐Education/ Academia
☐Others ( )	

Q 29: Have you spent a significant amount of time (two years or more) living outside Vancouver, but within Canada? If yes, please write down the name of the city that you have spent two years or more living in.

☐ Yes （Name of city： ） ☐ No

Q 30: Have you spent a significant amount of time (two years or more) living in another country? If yes, please write down the name of the country you have spent two years or more living in.

☐ Yes （Name of country： ） ☐ No

Q 31: Have you ever taken Biology/ Ecology/ Conservation-related classes or courses in school or independently?

☐Yes ☐No

Q 32: Are you currently participating in a group or organization which engages in activities related to nature or the environment?

☐ Yes ☐No

Q 33: Please select any to all of the following options which best describe your exposure to nature-related activities in the past one year:

☐I have visited a park for the purpose of participating in park bazaars and/ or festive events
☐ I have taken a walk in parks on a constant (weekly or fortnightly) basis.
☐ I have visited the Zoo/ Botanical gardens
☐ I have visited one of Canada's Nature Reserves
☐ I have spent time in rural areas
☐ Others（）

Q 34: (Optional) Do you have any comments or suggestions for this survey? If you would like to be updated about the findings from this research project, please feel free to write your e-mail address in this space.