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Understanding Demands for Ecosystem Services and Facilities in Urban Green Spaces

（都市緑地における生態系サービスおよび施設に対する需要の把握）

Hokkaido University　Graduate School of Agriculture

Division of Environmental Resources　Doctor Course

Hyerin Kim

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ACRONYM

CS	Consumer surplus
CV	Compensating variation
DCE	Discrete choice experiment
ES	Ecosystem services
ITCM	Individual travel cost method
KT model	Kuhn-Tucker model
NB model	Negative binomial model
PPCE	Partial profile choice experiment
SEF	Services from ecosystem and facilities
TCM	Travel cost method
UGS	Urban green spaces
WTP	Willingness-to-pay
ZINB model	Zero-inflated negative binomial model

1 Introduction

1.1 Background

1.1.1 Ecosystem services in cities

Ecosystems provide a wide range of goods and ecosystem services (ES) that are vital to people's well-being, health, livelihood, and survival (Millennium Ecosystem Assessment, 2005). The term "ecosystem services" was first used by Ehrlich et al. (1997) and has since been defined by various studies (Cork et al., 2001; Kremen et al., 2002; Millennium Ecosystem Assessment, 2005; Boyd and Banzhaf 2007; The Economics of Ecosystems and Biodiversity, 2010). The Economics of Ecosystems and Biodiversity report defined ES as "the direct and indirect contributions of ecosystems to human well-being," and divided ES into four main categories: provisioning, regulating, habitat, and cultural and amenity services, mainly following the "Millennium Ecosystem Assessment" classification (The Economics of Ecosystems and Biodiversity, 2010).

ES play important roles in cities, as they contribute to the quality of life of citizens (Daily, 1997; Bolund and Hunhammar, 1999; Takano et al., 2002; Chiesura, 2004; Andersson et al., 2007; Tratalos et al., 2007; Ernstson et al., 2010; Konijnendijk et al., 2013; Wolch et al., 2014). Therefore, the planning and management of ES in cities are becoming ever more crucial (Haaland and van den Bosch, 2015). One of the ES provided by urban natural areas are recreational opportunities for urban dwellers under a hectic working environment (Hammitt, 2002; Pincetl and Gearin, 2005; Irvine et al., 2009; James et al., 2009; Haq, 2011; Badiu et al., 2016). While urban natural areas provide types of recreation that are unique to natural areas, such as the observation of animals and/or plants, they also offer high quality environmental settings for walking or running (Mitchell and Popham, 2008; Arnberger and Eder, 2012). However, recreational opportunities are not the only ES expected in cities. Today, there are demands for new services that have never been required in cities previously. For example, conserving biodiversity in urban natural areas is an important issue in maintaining an urban ecosystem (Adams, 2005). There is also a growing call for parks to serve as evacuation sites in the event of natural disasters (Yun, 2007). In addition, cultural services can be mentioned as one of ES in cities, as can be seen in the outdoor exhibition of artworks in parks and green spaces. To provide high quality ES in cities, policymakers need to understand the contemporary preferences for ES itself as well as the preferences for various environmental settings and facilities that provide ES (e.g., trails in greenways and museums in parks). This dissertation focuses on urban green spaces and attempts to apply environmental valuation methods to quantitatively valuate the benefits of ES and facilities that are provided by urban green spaces (hereafter referred to as services from ecosystem and facilities, or SEF).

In this dissertation, the definition of urban green spaces (UGS) is vegetated space, and mainly focuses on parks. The definition of UGS will be used in varying disciplines, cultures, and contexts (Hunter and Luck, 2015; Taylor and Hochuli, 2017). It can take place in many shapes, forms, functions, and purposes, and they may be very different from one community to another (Rakhshandehroo et al., 2017). According to Jennings and Bamkole (2019), "UGS" refers to areas such as gardens, parks, greenways, and other areas with grass, trees, and/or shrubs. As for Taylor and Hochuli (2017) and Chong et al. (2013), UGS can be interpreted as green space. Chong et al. (2013) defined green space as any vegetated land adjoining an urban area, including bushland, nature reserves, national parks, outdoor sports fields, school playgrounds, and rural or semi-rural areas. In Sapporo city, which is located in the study area, has its own definition of UGS called "Midori." However, while the definitions of UGS are different depending on the disciplines, cultures, and context, the roles of UGS are relatively similar.

1.1.2 Challenges on urban green spaces

In Japan, the government has made significant efforts to increase the area of UGS. In the past, policymakers focused mainly on the beauty of the facility and the landscape.

For example, they simply planned to provide playgrounds for children, and places for trees and lawns. As mentioned before, the demands for SEF are becoming increasingly diverse, with traditional environmental settings and facilities in UGS often not meeting the demands of contemporary UGS visitors. The contemporary visitor structure is also drastically changing. Given Japan's declining birthrate and aging population, the main UGS visitors have shifted gradually from children to the elderly. The rapid decline in the birthrate and the rise in aging population have created significant new policy challenges (Raikhola and Kuroki, 2009). For example, in the Sapporo city area, UGS tend to think in terms of the development of facilities for the elderly instead of playgrounds for children.

Because of such social situations, in the Sapporo city area, many UGS facilities are in the process of renovation, since the development of most of the UGS in the area occurred before the 1970s. Planning renovations requires policymakers to understand general public's preferences for SEF in UGS. Speaking of recreation—one of the most important ES in UGS—there is certainly some understanding of how many visitors use the facilities. However, it has not been clarified what gender or age the visitors are, or what their motivation is when visiting, for example. Regarding contemporary SEF plans, such as conserving biodiversity and providing evacuation sites, it is not clear even if such SEF are really being required by people.

Furthermore, it is not enough to simply understand general public's preferences for SEF in UGS. Under austerity conditions, there is no budget even for updating the current environmental settings and facilities. Under a limited budget for renovation, policymakers must consider the most efficient way to increase the satisfaction of urban-dwellers. To this end, it is necessary to quantitatively understand how much benefit is provided by recreational opportunities, and how much benefit would be provided by SEF such as conserving biodiversity and providing evacuation sites. That is, a cost–benefit analysis is ultimately needed. Failure to consider these benefits properly can lead to excessive (or insufficient) facility renovation that is incompatible with the demand, or there may be a problem with economic efficiency, in which the provided recreation is in conflict with the recreation required by the visitor. This dissertation mainly focuses on valuating the benefits side using environmental valuation methods.

1.2 Purpose of this dissertation

1.2.1 Understanding recreation demand

One of the purposes of this dissertation is to understand recreational demands in the Sapporo city area, northern Japan. This dissertation targeted 29 large UGS in the Sapporo city area. In Chapter 4, to understand the recreation demands of 29 UGS, two types of travel cost method were applied—specifically, individual travel cost method and Kuhn-Tucker model. Although the research questions will be described again in detail in a later chapter, those for a case study using the individual travel cost method were as follows:

- How much recreation benefit is generated by each UGS?
- What visitor characteristics (e.g., gender, age, and motivations to visit) affect the recreation benefit at each UGS?

The individual travel cost method is applied to each of the 29 UGS, and the recreation benefit of each is estimated. In contrast, Kuhn-Tucker model tries to construct a recreation demand system for 29 UGS, using visitor characteristics and site characteristics (e.g., whether or not barbecue areas are provided). Research questions for the case study using the Kuhn-Tucker model were as follows:

- What visitor characteristics and site characteristics affect the recreation benefit of UGS in the Sapporo city area?
- Is it efficient to expand each UGS by 1 hectare from the viewpoint of a cost–benefit analysis?

With the growing demands for recreation (e.g., walking or running), expectations for UGS are increasing in the Sapporo city area. Therefore, policymakers are also interested in determining whether it is appropriate to expand UGS. If a recreation demand system can be constructed using the Kuhn-Tucker model, the benefit of expanding each UGS by 1 hectare can be estimated. By comparing benefits with costs (the posted land prices near each UGS), the economic efficiency of expanding each UGS can be confirmed.

1.2.2 Understanding benefit from ecosystem services and facilities

In addition to the recreational benefit, there is also a need to valuate the benefits of contemporary SEF in UGS. In particular, ES that provide non-use value, such as the conservation of biodiversity and environmental setting, as well as facilities that are not currently offered, such as evacuation sites, cannot be valuated by the travel cost method. Therefore, in Chapter 5, partial profile choice experiment was applied to estimate the benefit from SEF. The research question is as follows:

- How much benefit would be generated by providing SEF in UGS to the general public?

Although research questions will be described in detail in a later chapter, the focuses in this chapter are on 1) estimating willingness-to-pay for contemporary SEF, such as conserving biodiversity and providing evacuation sites, and on 2) estimating willingness-to-pay for facilities for children and the elderly, and discussing the reduction of facilities for children in UGS because of the low birthrate and aging population.

1.2.3 Novelty of this dissertation

The novelty of the case study using the individual travel cost method is as follows. First, it valuates recreation benefits at multiple UGS, and interprets these by considering the spatial layout. So far, many previous studies performed benefit valuations at a specific recreational sites. However, only a limited number of valuations have been performed for multiple recreation sites in a particular area. Second, the case study attempts to consider excess zeros. An analysis is performed using the number of visits as a response variable in the individual travel cost method. However, an off-site survey targeting the general public, which was performed in this study, includes excess zeros in the data. For solving this problem, a zero-inflated negative binomial model was applied. There is only a limited number of examples in which the model is used to valuate recreational benefits.

The novelty of using the Kuhn-Tucker model is as follows. The first is that, unlike the individual travel cost method, site characteristic that affects the number of visits of UGS can be considered. Second, it is the first study to apply the Kuhn-Tucker model to the valuation of recreation in UGS. Although, several different subjects, beginning with the valuation of outdoor recreation, have been valuated using this model in case studies up until now, this particular model has not been used for the valuation of UGS. Third, the proposal of an approach to determine the economic efficiency of the expansion of UGS at the city level is possible. With respect to a single UGS location, it is possible to valuate the benefits obtained through the expansion of UGS by a set area using the individual travel cost method and contingent behavior method. However, it is difficult to apply these methods in situations in which the expansion of several UGS by various areas is assumed.

Finally, the novelty of using the partial profile choice experiment is as follows. Both the individual travel cost method and the Kuhn-Tucker model makes it possible to understand the benefit of recreation. However, these methods cannot help understand the benefit of non-use value, such as conserving biodiversity and providing evacuation sites. On the other hand, the partial profile choice method can take these attributes into analysis. Also, it is possible to consider diverse ES and facilities at the same time. In a conventional discrete choice experiment, only a few attributes (i.e., ecosystem services and facilities) can be considered.

2 Study site

2.1 Sapporo city area

2.1.1 Overview

The city of Sapporo is located in the Hokkaido prefecture, an island in northern Japan (Figure 1). The population of Sapporo city is around 1.9 million, which makes it the fifth largest city in Japan. The study site is the Sapporo city area that includes Ebetsu, Kitahiroshima, and Ishikari cities as well as Sapporo city.

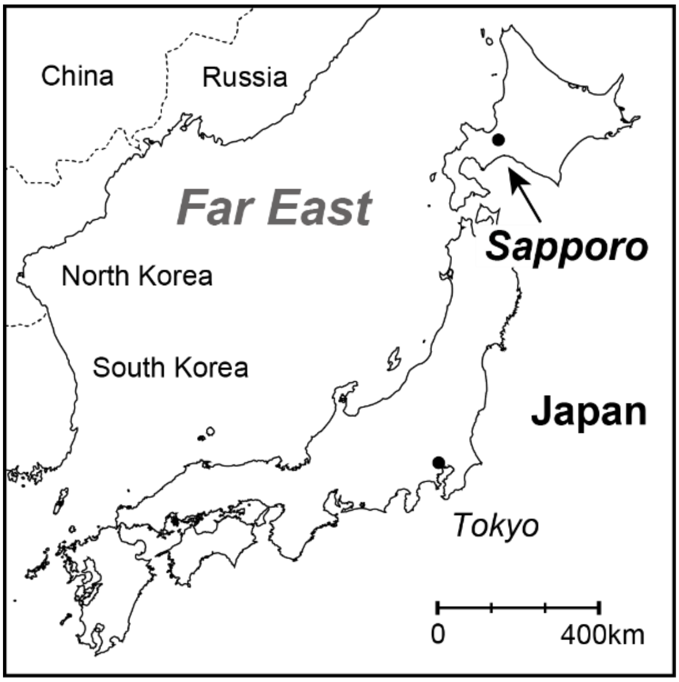

Figure 1. Study area

2.1.2 Expected services in urban green spaces

According to the report of Management Policy for Urban Parks in Sapporo (City of Sapporo, 2017), UGS is defined as a facility with various functions, such as a space covered with rich greenery and a space where citizens can relax. The effects of the existence of UGS are diverse. Therefore, if various functions are fully utilized, the values as social capital will increase.

First, UGS create a safe and secure urban infrastructure. Open spaces, such as parks and green spaces, function as evacuation sites and zones to prevent the spread of fire in the event of a disaster. Therefore, UGS can be possible to enhance the security of the town and the feeling of relief by citizens by appropriately arranging and networking the UGS. Second, UGS allow environmental maintenance and improvement. For example, building an urban structure can negatively affect biodiversity. UGS can conserve biodiversity as well as providing other environmental resources such as clean air and water. Additionally, UGS suppress the urban heat island in large cities and act as a place for snow collection in winter. Third, UGS offer a place for health and recreation. UGS are places for recreational activities such as sports, running, and walking, which also promote health. In addition to increasing leisure time and diversifying value, UGS also serve as places to enjoy gardens and nature. Fourth, UGS make the scenery of Sapporo unique. For example, the rivers and mountain ranges that surround the town, such as Mt. Moiwa and Toyohira river, provide atmosphere and form Sapporo’s beautiful scenery. Trees and flowers suitable to the climate decorate the streets throughout the four seasons, and create unique landscapes by preserving and creating both historic and iconic Midori. Fifth, UGS help regional culture be passed on to new generations. Cultural events as well as historical spots are located in these areas. Citizens can visit museums and view exhibitions about tradition and history in some parks in the city. Sixth, UGS provide spaces for childcare and education. Many UGS have playgrounds for children. These contribute to the physical health of children. In addition, learning opportunities and experiences are abundant in UGS, not just through the natural environment, but also in facilities such as the observatory in Nakajima park. Seventh, UGS are spaces were citizens can interact with the community. Citizens who have common interests such as sports or birdwatching gather and connect with each other. Eighth, tourism can be promoted by UGS. Seasonal events and unique attractions entice many foreigners and non-locals to visit the city. For example, events such as the Snow Festival in Odori park brings in a large number of tourists every winter. Ninth, UGS have an economic activation effect. This means that UGS stimulate economic growth by promoting corporate locations and creating jobs. For example, many hotels and restaurants are built around UGS. Table 1 shows the expected services of the UGS.

Table 1. Expected services of urban green space

Expected services of urban green space	**Contents**
Disaster prevention improvement	Improving the safety of citizens by functioning as a refuge in the event of a disaster
Environmental maintenance, improvement	Improving city environment such as securing biodiversity and suppression of the urban heat island
Health and recreation space provision	Promotes physical and mental health
Landscape formation	Providing a feeling of seasonality, enhancing the town scenery
Cultural heritage	Passing down of regional culture
Childcare, education	Providing a healthy upbringing space for children
Communication shaping	Providing a space for community communication and a place for citizen participation
Tourism promotion	Creating and revitalizing local value such as attracting tourists
Economic activation	Promoting economic growth by promoting corporate location and creating jobs

2.1.3 Challenges: Demand shift

Recently, citizens' awareness of ES in UGS has increased, which diversified demands for ES, and thus traditional UGS no longer meet the demands of current users. Therefore, park managers must respond to the changes in demand.

Today, new forms of cultural service have also been appearing in UGS, such as outdoor exhibitions in the Sapporo art park, located in the Sapporo study site. In addition, there is need for more habitats for wild animals and plants (Adams, 2005). For example, Fuyuki et al. (2014) found that the city area plays an important role as a habitat for amphibians. The conservation of their habitats in urban areas is becoming more important for the public as well as academics and organizations in charge of wildlife conservation.

2.1.4 Challenges: Low birthrate and aging population

Second, it is necessary to consider the change in users due to the social phenomena of the low birthrate and aging population. It is one of the Japan's main problems at present, affecting Sapporo city as well. According to the report of Cabinet Office (2017), the number of people aged 0–14 in 2017 is 1,559, which is about 15% lower than the total in 1970, which was 10,467, and is expected to decrease gradually over time. In particular, the fertility rate decreased to 1.44% in 2016 as compared with 2.14% in 1973. On the other hand, the aging rate is on the rise. The rate of aging, which was 7.1% in 1970, was 28% in 2017, an increase of about 21%, and it is expected to increase (Cabinet Office, 2017). This trend indicates that the hierarchy of users has changed since the 1970s, when UGS planning began. This suggests that the current UGS' management needs to be planned to reflect these phenomena. Current services and facilities may not match the needs or requirements of the elderly, which in recent years have resulted in the provision of facilities for elderly people instead of renovating facilities for children in the area.

2.1.5 Challenges: New services

Third, there are demands for new services that have never before been required for UGS. For example, there is a growing call for UGS to serve as providing evacuation sites in the event of a disaster. Due to its geographical position, large earthquakes occur frequently in Japan. This may be related to recent severe natural disasters, which are argued to have intensified with global warming. Central Sapporo has many high-rise apartment buildings, and if these were damaged, many citizens would be forced to evacuate. The UGS management policy in the Sapporo area has stated that UGS are available as evacuation sites in times of disaster (City of Sapporo, 2017). Indeed, UGS have already played an important role as a refuge during evacuations, providing a safe and effective disaster prevention space in Japan (Yun, 2007).

2.1.6 Renovation plan for urban green spaces

The City of Sapporo is considering renovation for UGS in due to the deterioration of facilities. Most of the facilities were built in before the 1970s, when early UGS policies were in place. According to the report of the Management Policy for Urban Parks in Sapporo (City of Sapporo, 2017), 60% of the facilities are at least 30 years old, which is the aging standard of UGS. In addition, the renovation of UGS facilities in the past was done with the provision of standard recreational opportunities in mind. For example, playground equipment was set up in most of the large UGS. However, the low birthrate and aging population is increasing in the Sapporo city area (City of Sapporo, 2017), thus there is a possibility that a playground facility may not be used as frequently. Additionally, the number of people who walk or run has been increasing rapidly in recent years (Japan Sports Agency, 2019) because of the change in people's awareness about maintaining their health. The current renovation plan is made to address changes in the visitor composition to UGS and their aging facilities (City of Sapporo, 2017). While park management needs to respond to such visitor group changes via renovation, managing the UGS's financial sustainability is also required.

Due to the large number of target UGS and UGS facilities, combined with budgetary and personnel constraints, it is currently difficult to maintain a sufficient level of updating and maintenance, and carry out large-scale reorganization work for all the facilities. Therefore, it has been discussed that the large UGS in the city areas should be categorized according to their usage and the importance of their locations. This allows policymakers to focus on certain types of renovation to be done depending on the needs of each UGS instead of creating a general plan for all UGS.

2.2 Setting up target sites

2.2.1 Study sites: 29 urban green spaces

In this dissertation, some criteria were set for the selection target sites which is 29 UGS. The selection process for 29 locations is as follows. First, referring to the renovation plan and considering research questions, the existing ward divisions of the study site were considered, followed by park classification criteria. According to the classification of the park by the Ministry of Land, Infrastructure, and Transport (2010), there are 12 park classifications, including greenways (Table 2).

Table 2. Types of city parks

Types	Classification	Description
Basic parks for community use	City block parks	To be placed for the use of most nearby residents; their standard area is 0.25 hectare per park, and each is intended to be used by residents who live within a radius of 250 m.
	Neighborhood parks	To be placed for the use of residents who live in the neighborhood; one neighborhood park will be provided in each neighborhood unit. Their standard area is 2 hectare par park, and each is intended for use by residents who live within a radius of 500 m.
	Community parks	To be placed for the use of those who live within walking distance; their standard is 4 hectare or more for specific district parks (specified community parks) in certain municipalities that are not covered by urban planning areas.
Basic parks for city-wide use	Comprehensive parks	To be placed for the use of all residents in a city for various purposes, including rest, walking, playing, and sports; their standard area ranges from 10 to 50 hectare according to the size of the city.
	Sports parks	To be placed for the use of all residents in a city, mainly for athletic activities; their standard area ranges from 15 to 75 hectare according to the size of the city.
Large-scale parks	Regional parks	To be placed for the purpose of satisfying area-wide weekend recreation needs of residents of more than one municipality. Their standard area is at least 50 hectare and their recreational facilities are placed organically.
	Recreation cities	Areas where a variety of recreation facilities are provided, mainly in a large-scale urban park; these cities aim at meeting area-wide recreation needs of residents of large cities or of other cities, which are constructed in accordance with a comprehensive city plan. Total area will be 1,000 hectare.

National government parks		Large-scale parks established by the government for use by residents of more than one prefecture; their standard area is at least 300 hectare per park; when these parks are constructed as a commemorative project by the government, they should have facilities suitable for their objectives.
Buffer green belts	Specific parks	Special parks, such as scenic parks, zoos and botanical parks, historical parks, cemeteries, etc. are set up in accordance with their objectives.
	Buffer greenbelts	Greenbelts intended to help prevent or reduce pollution such as air contamination, noises, vibrations, and bad odors, or to prevent disasters in industrial complexes, etc. They are provided at locations where sources of pollution or disasters must be separated from residential or commercial areas.
	Ornamental green spaces	Green space provided to maintain and improve natural environment of a city and to create a better urban landscape. Their standard area is at least 0.1 hectare per lot; when there are existing woods, etc., in an established city area, or when greenbelts are provided by planting trees for a better urban environment, the standard area is 0.05 hectare or more.
	Greenways	Greenbelts that are mainly composed of passages with tree plantings, pedestrian ways or cycling courses. They aim to provide secure escape routes in an emergency. They naturally connect parks to houses, schools, shopping centers, etc.

Resouce: Ministry of Land, Infrastructure, Transport and Tourism (2010)

www.mlit.go.jp/english/2006/d_c_and_r_develop_bureau/03_parks-and-green/ (Access 3 April, 2019)

Among these, in consideration of the relatively large UGS being considered for renovation in Sapporo, the city block parks, neighborhood parks, and community parks were excluded. The greenways were also considered to be unsuitable places to achieve the research goals, so they were also excluded from the list of classification of target sites in this dissertation. Therefore, comprehensive parks, sports parks, regional parks, national government parks, specific parks, buffer greenbelts, and ornamental green spaces were applied as classifications of the target site. In addition, since two UGS that did not fit the types of city parks were mentioned in expert interviews as important sites for renovation, natural park (i.e., Nopporo forest park) and facility (i.e., Sapporo satoland) were also included in the classification of target sites in this dissertation. Also, the selection of target sites was conducted primarily based on area, wherein UGS with areas of 10 hectare or greater were selected. The reason for selecting UGS with 10 hectare or more of area was as follows. First, as renovations are being planned for large UGS, selecting large UGS with areas of 10 hectare or more means that almost all of them are included in renovation plans. Second, in Chapter 4, it was necessary to ask respondents how many times they visited each target UGS, thus the number of valuation subjects was restricted to reduce the burden placed on respondents. Third, a hypothetical scenario was used to understand the general public's preference in Chapter 5, thus, UGS that were well-known by the general public were needed for this study. However, Odori park was included in the selection despite having an area of less than 10 hectares. This is because despite its small area, clearly has a large number of users, so it was also selected for valuation. Finally, a total 29 UGS were set as the study sites. Detailed information is shown in Table 3.

Table 3. Type and area of 29 urban green spaces in the Sapporo city area

Name	**Type**	**Area(1,000m^2)**
Gotenzan park	Comprehensive parks	246
Hiraoka park		663
Kawashimo park		195
Maeda forest park		597
Maruyama park		687
Moerenuma park		1,037
Monami park		297
Nakajima park		236
Tsukisamu park		218
Yurigahara park		254
Ryokuyo park		478
Aoba park	Sport parks	131
Atsubetsu park		132
Ishikari river riverbed green space		145
Noshi park		124
Teine inazumi park		182
Makomanai park	Regional parks	847
Takino suzuran hillside national government park	National government parks	3,957
Asahiyama memorial park	Specific parks	203
Miyagaoka park		332
Nishioka park		410
Odori park		79
Sapporo art park		390
Hoshimi green space	Buffer green belts	155
Ishiyama green space	Ornamental green spaces	119
Toyohiragawa green space		1,238
Yamaguchi green space		444

Nopporo forest park	Natural parks	20,510
Sapporo satoland	Facilities	743

3 Method

3.1 Environmental valuation method

3.1.1 Overview

In economics, a market is defined as a place where goods and services are traded using monetary products and monetary information. Thus, environmental goods and services, which lack a market, are called non-market goods (or services). These goods and services cannot be traded in market because they do not have a monetary value or price (Millennium Ecosystem Assessment, 2005; Abdullah et al., 2011). However, it is important to economically price these goods or services to reflect value. To assess the economic value of non-market goods and services, it is necessary to understand the various components that make up the total economic value (Abdullah et al., 2011). Conceptually, the total economic value of environmental resources consists of both use and non-use values (Pearce and Moran, 1994; Abdullah et al., 2011). Figure 2 shows the general framework for the value of environmental goods and services.

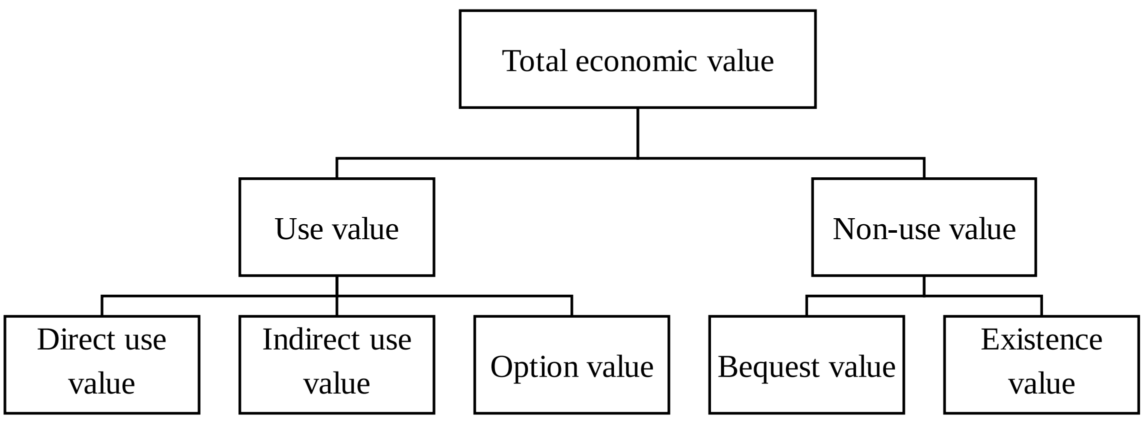

Figure 2. Framework of total economic value

“Use value” refers to the value of ES that come from the use of resources for consumption or production purposes (Millennium Ecosystem Assessment, 2005; Abdullah et al, 2011)—for example, the production of timber for use as building materials. Use value can be categorized further into direct use, indirect use, and option values (Pearce and Moran, 1994; Millennium Ecosystem Assessment, 2005). Direct use value includes values of goods and services actually used for consumptive purpose (Millennium Ecosystem Assessment, 2005; Abdullah et al, 2011). It includes the harvesting of food products, manufacturing medicinal products, and hunting for animals. Indirect use value, on the other hand, refers to the benefits received from ES such as watershed protection (Pearce and Moran, 1994; Millennium Ecosystem Assessment, 2005; Abdullah et al, 2011). Option value is the value that arises from potential availability. That is, this value may not be derived currently, but it adds value that might be used in the future (Millennium Ecosystem Assessment, 2005; Abdullah et al, 2011).

On the other hand, “Non-use value” refers to the value of environmental goods and services that is not derived from use or consumption directly (Millennium Ecosystem Assessment, 2005; Abdullah et al, 2011)— for example, when people are simply satisfied with the existence (Millennium Ecosystem Assessment, 2005) and maintenance of the environment (Abdullah et al, 2011). Non-use value can be categorized as bequest value and existence value (Pearce and Moran, 1994; Abdullah et al, 2011). Bequest value is the benefit accruing to any individual from the knowledge that others might benefit from a resource in future (Pearce and Moran, 1994; Abdullah et al, 2011). On the other hand, existence value, also known as passive use value, refers to the value that can be given simply by the existence of environmental goods (Pearce and Moran, 1994; Abdullah et al, 2011). Depending on which value is to be estimated, the valuation method to be used varies (Abdullah et al, 2011). There are various ways of valuating non-market goods and services, but the two main methods are the stated preference method and the revealed preference method (Figure 3).

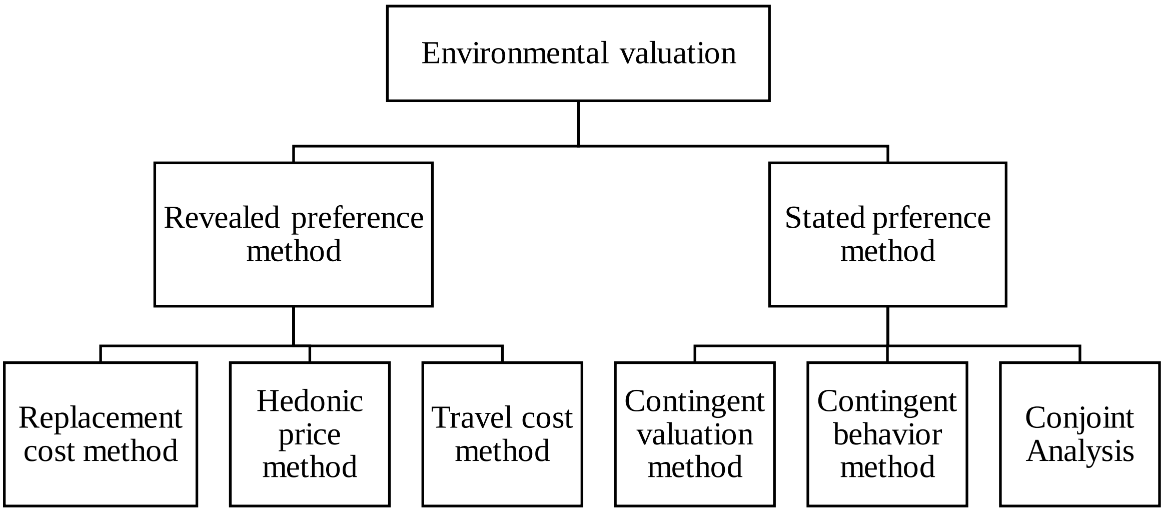

Figure 3. Framework of environmental valuation

A revealed preference method is an indirect approach that uses market data based on established and actual recorded behavior (Abdullah et al., 2011). The revealed preference methods include the replacement cost method, the hedonic price method, and the travel cost method. On the other hand, a stated preference method is a direct approach and is hypothetical in nature (Abdullah et al., 2011). The stated preference method includes the contingent valuation method, the contingent behavior method, and conjoint analysis. The purpose of this dissertation is to use both the revealed preference method and the stated preference method to identify general public's recreational benefit of UGS and preference of SEF from UGS.

3.1.2 Travel cost method: Overview

The travel cost method (TCM) is well-known as a method for estimating recreational values (Zhang et al., 2015). The original idea of TCM was attributed to Hotelling (1947) in a release on the economics of recreation in US national parks by the National Park Service (Ward and Beal, 2000). Hotelling suggested measuring differential travel rates according to travel distances that visitors overcame in reaching a park from the place of residence to the park area (Ward and Beal, 2000). Beginning with initial work by Clawson (1959) and Trice and Wood (1958), and later Knetsch (1963) and Clawson and Knetsch (1966) were also instrumental in further development of TCM (Ward and Beal, 2000; Phaneuf and Smith, 2005). TCM is broadly categorized into three models: the single-site model, the multi-site model, and the Kuhn-Tucker model. The single-site model is generally used to understand the demand for a specific recreation site (Brown et al., 1983; McConnell, 1985). On the other hand, the multi-site model has been applied to valuate the benefits created by environmental attributes at recreational sites rather than understanding the demand for a specific recreation site (Brown et al., 1983; McConnell, 1985).

The single-site model of TCM can be divided into the zonal travel cost method and the individual travel cost method (ITCM), according to the dependent variable (Das, 2013). Since individual data is consolidated by each zone in the zonal travel cost method, which was used at an early stage, it was not possible to understand the relationship between the number of visits and individual attributes/motivations to visit (Brown and Nawas, 1973; Bennett, 1996; Asafu-Adjaye, 2005; Rolfe and Dyack, 2011). On the other hand, the ITCM made it possible to understand the relationship. The ITCM was first developed by Brown and Nawas (1973), and it estimates the individual's recreation demand functions. Statistical methods have advanced in recent years, and the ITCM has been used widely as a method to understand recreational demand (Zhang et al., 2015). ITCM can elicit the factors affecting the number of visits using individual attributes in the analysis (e.g., age, gender), but it is difficult to consider the effect of site characteristics. Details about the ITCM are discussed in Chapter 4.

The Kuhn-Tucker model (KT model) is a suitable method that combines characteristics of both the single-site model and the multi-site model (Phaneuf et al, 2000; von Haefen et al, 2004). It can model simultaneous decisions regarding which sites to visit and how many trips to make to each site over the course of a season (Sánchez et al., 2016). KT model was initially developed by Hanemann (1978) and Wales and Woodland (1983). After that, it was used by Herriges et al. (1999) and

Phaneuf and Siderelis (2003) for benefit measurement. Phaneuf et al. (2000) applied the KT model to the analysis of fishing in the Great Lakes in Wisconsin. The key feature of the KT model is that consumers' choices regarding which sites are visited and the number of visits made to each site are integrated into each other as "linked" models of recreation demand (Herriges et al., 1999), in accordance with utility theory. Details about the KT model are discussed in Chapter 4.

There are some challenges in the application of TCM. First, the purpose of the trip varies. For example, considering people who visit multiple destinations during a travel, it is very difficult to calculate the cost of travel for each destination (Harrison, 2001). In this case, there is a method of removing the multipurpose traveler from the sample, but there is a problem in that the natural estimated value is biased. Second is the estimation of travel costs. For example, if someone buys shoes for hiking, the decision to include them in the travel costs is complicated. Moreover, in the case of opportunity costs, there is no clear definition as to whether they can be properly included in the calculation of travel costs (Fletcher et al., 1990; Randall, 1994). According to Cesario (1976), the value of travel time is estimated to be about one-third of the hourly wage rate, but it is controversial as to whether it is applicable in all situations.

3.1.3 Discrete choice experiment: Overview

Discrete choice experiments (DCE) allow the analysis of respondents' willingness-to-pay (WTP) for various attributes of a good or service. DCE is one of the stated preference methods, which is derived from conjoint analysis, a technique designed to analyze consumer choices in the field of marketing (Green and Srinivasan, 1978). Adamowicz et al. (1994), who assessed recreation in Canada, was the first to use DCE for environmental goods.

The advantage of the DCE is that WTP can be obtained by adding a cost variable to the attribute. For the hypothetical scenarios presented, respondents did not have to specifically express their WTP for the product in terms of monetary value, because they were given several set choices. Respondents' responses to the question also allow researchers to identify and choose possible alternatives that can be implemented at minimal cost. Because of these advantages, DCE has been widely used in the fields of marketing, transportation, and healthcare (Cunningham et al., 2006; Nielsen and Amer, 2007; Bridges et al., 2011; Martin-Collado et al., 2014; Kessels et al., 2015). With regard to environmental management problems, DCE was first applied by Adamowicz et al. (1994) to valuate recreationalists' preferences for alternative flow scenarios for the Highwood and Little Bow Rivers in Alberta, Canada.

However, one problem with conventional DCE is that the number of attributes it can valuate is limited (Bateman et al., 2002; Holmes and Adamowicz, 2003). In DCE, a profile is constructed from many attributes, which increases statistical efficiency but decreases respondent efficiency. Thus, as an alternative, a partial profile choice experiment (PPCE) was introduced as a method of adapting DCE to handle large numbers of attributes (Chrzan and Elrod 1995; Chrzan, 2010). In this dissertation, PPCE, which is an applied method of DCE, was applied and details about the PPCE will be discuss in Chapter 5.

3.2 Travel cost method

3.2.1 Model framework: Individual travel cost method

The single site model is used to calculate the demand for travels to a recreation site by a person over a certain period (Parson, 2003). In this dissertation, ITCM which is one analysis of the single-site models was applied. The following shows the simplest form the ITCM.

$$r = f(tc_r), \qquad (1)$$

where r is the number of travels by a person in a season to the recreation site, and tc_r is the travel cost needed to reach to the site (Parson, 2003). However, travel cost alone is not enough to explain an individual's demand for recreation travels (Parson, 2003). Many things such as age, income, etc., affect an individual's recreation travels. Therefore, equation (1) can be adjusted as follows.

$$r = f(tc_r, y, z), \qquad (2)$$

where tc_s represents a vector of travel costs to other recreation sites, y represents income, and z is a vector of demographic variables that are believed to affect the number of travels (Parson, 2003). The result of the TCM reveals consumer surplus (CS). The value of UGS is represented by the total CS, which indicates the difference between an individual's total WTP for travels and the actual travel cost incurred over a season, under the single site demand function (Parsons, 2003). A more general expression for CS, is the area under the demand curve between an individual's current travel cost, and the choke price (Figure 4). Choke price is the price at which trips fall to zero in the model (Parsons, 2003).

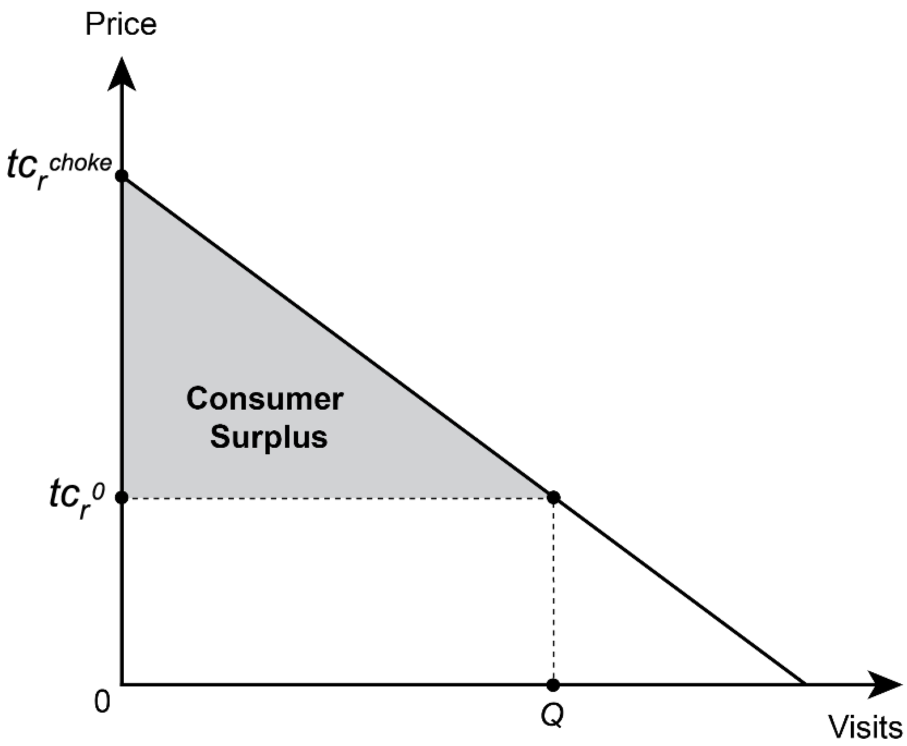

Figure 4. A consumer surplus

As shown in Figure 4, CS represents the area underneath the demand curve up to the number of trips consumed and the value above travel costs that consumer incur by visiting a recreation site (Parsons, 2003). The CS can be computed as follows.

$$CS = \int_{tc_r{}^{0}}^{tc_r{}^{choke}} f_i = (tc_r, y, z)dtc_r, \qquad (3)$$

where $tc_r{}^{choke}$ is the choke price and $tc_r{}^{0}$ is the individual's travel cost (Parsons, 2003).

3.2.2 Model framework: Kuhn-Tucker model

The KT model considers the following utility maximization problem

$$\max_{x,z} U(x, z, q, \gamma, \varepsilon) \qquad (4)$$

$$s.t.\ \ p'x + z = Y,\ \ z > 0,\ \ x_M \geq 0,\ \ M = 1, \cdots, M,$$

where U is the utility function, $x = (x_1, \cdots, x_M)'$ is a vector of visits to sites (x_M is the number of visits to site M), z is a numeraire good whose price is normalized to one and assumed to be necessary goods, $q = (q_1, \cdots, q_M)'$ is a vector of attributes of the sites, γ is a vector of the parameters, $\varepsilon = (\varepsilon_1, \cdots, \varepsilon_M)'$ is a vector of error term, $p = (p_1, \cdots, p_M)'$ is a vector of travel cost from the residence of the respondent to site, and Y is income.

This utility maximization problem refers to maximizing utility for a consumer for a certain period under both budget constraints and non-negativity constraints of the number of visits to each UGS. To solve this problem the following conditions are obtained

$$U_j \leq U_z p_j, \quad x_j \geq 0, \quad x_j\left[U_j - U_z p_j\right] = 0, \quad j = 1, \ldots, M. \qquad (5)$$

Here, $U_j = \partial U / \partial x_j$ and $U_z = \partial U / \partial x_z$. These conditions indicate that, in cases in which the number of visits to a UGS is 1 or greater, the number of visits is determined such that the utility obtained from a visit and the marginal rate of substitution of the numeraire is equal to the travel costs, but if the number of visits is 0, that is, for the corner solution, the utility obtained from a visit and the marginal rate of substitution of the numeraire is less than or equal to the travel costs.

Here, if g_j is set as the solution of the following equation,

$$\widehat{U_j}\left(x, q, M - p'x, \beta, g_j\right) - \widehat{U_z}\,(x, q, M - p'x, \beta) = 0. \qquad (6)$$

Equation (6) can be organized as

$$\varepsilon_j \leq g_j(x, y, q, \gamma), \quad x_j \geq 0, \;\; x_j[\varepsilon_j - g_j] = 0, \quad j = 1, \dots, M, \qquad (7)$$

The probability that the number of visits will be 1 or greater is $\Pr(x_j = x_j^*) = \Pr(\varepsilon_j = g_j)$ and the probability that the number of visits will be 0 is $\Pr(x_j = 0) = \Pr(\varepsilon_j < g_j)$. From this fact, the probability of visiting the first k UGS can be expressed as

$$\int_{-\infty}^{g_{k+1}} \dots \int_{-\infty}^{g_M} f_\epsilon(g_1, \dots, g_k, \varepsilon_{k+1}, \dots, \varepsilon_M) \times |J_k| \, d\varepsilon_{k+1}, \dots, d\varepsilon_M, \qquad (8)$$

where $|J_k|$ is the Jacobian transformation from ε to $(x_1, \cdots, x_k, \varepsilon_{k+1}, \cdots, \varepsilon_j)'$, and abs$|J_k|$ expresses its absolute value. If f_ε, the distribution of ε_j, is assumed to follow a type I extreme value distribution of the scale parameter μ, then the likelihood function can be set and parameter β can be estimated.

Using indirect utility function V derived from the utility maximization problem (4), the compensating variation (CV) arising from the change in travel cost and attribute from (p^0, q^0) to (p^1, q^1) is defined as

$$v(p^0, q^0, Y, \beta, \varepsilon) = v(p^1, q^1, Y - CV, \beta, \varepsilon). \qquad (9)$$

Using expenditure function e, it is defined as

$$CV = Y - e(p^1, q^1, U^0(p^0, q^0, Y, \beta, \varepsilon), \beta, \varepsilon). \qquad (10)$$

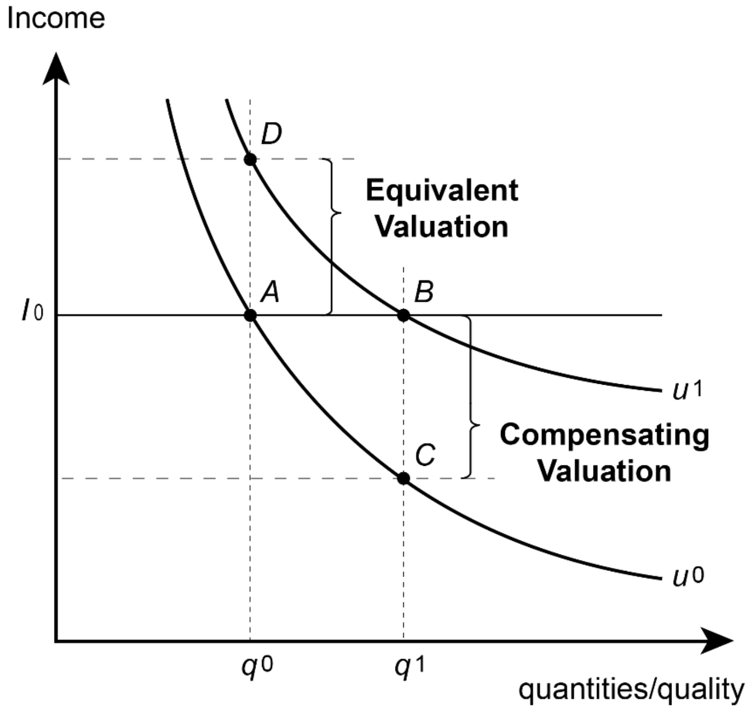

Figure 5. A compensating valuation and equivalent valuation

As CV (Figure 5) is a random variable for the researcher, only the expected value of CV can be computed, which is denoted as $E(CV)$. However, no closed-form solution for $E(CV)$ exists because constant elasticity of substitution and linear expenditure system, which are often assumed for the utility function, are nonlinear in income. Numerical methods such as the bisection approach are necessary to calculate $E(CV)$.

3.2.3 Travel cost estimation

Travel cost is applied to both the ITCM and KT model. To calculate the visitor's travel costs, Car_i and $Time_i$ need to be calculated. Accommodation fees were not considered, because some of the 29 sites do not charge admission fees for using UGS. Travel cost was calculated as

$$TC_i = Car_i + Time_i, \qquad (11)$$

where TC_i denotes the total travel cost that visitor i incurred to visit UGS, Car_i is a round-trip expense that visitor i spent by car during the trip. $Time_i$ denotes visitor i's time and opportunity cost to visit UGS. Specific calculation of each variable in the above equation is as follows. Car_i was calculated by the road distance from the visitor's residence to each UGS, assuming they visit UGS by car. It was expected that some vistors used public transportation to visit the UGS or walked to the UGS. However, considering that not all UGS are accessible by public transportation, and that each respondent is different in the distance they can walk, in this disseerataion the travel cost is substituted by the cost required to visit by car. The Car_i costs is calculated as

$$Car_i = \frac{Dist(km)\times 2}{10(km/l)} \times 133(yen/l). \qquad (12)$$

To estimate a fuel cost, the total distance of using a car needed to be calculated first. $Dist$ is the distance from visitor's residence to each UGS multiplied by 2 for a round trip. Then, it is divided by $10\ km/l$, which the furthest distance that a car can be driven with a certain amount of fuel consumption, and then multiplied by the average gasoline price at the time of data collection. In this dissertation, the price of gasoline—based on the average gasoline price during the survey period, was taken from the petroleum product survey (Agency for Natural Resources and Energy, 2017). The $Time_i$ is calculated as

$$Time_i = TT_i \times 2 \times 3325(yen/h) \times 1/3. \qquad (13)$$

TT_i refers to the one-way travel time, multiplied by two for a round trip. This is then multiplied by opportunity cost. Handling the opportunity cost for travel creates a major challenge for the TCM (Borzykowski et al., 2017) and there is no proper solution. Therfore, this dissertation uses one-third of the average wage rate as proposed by Cesario (1976). The average wage rate is calculated based on the Family Income and Expenditure Survey in 2017 (Statistics Bureaue of Japan, 2017). In Hokkaido, 3325 JPY per hour was the average wage rate. The average wage per hour was calculated by using the following formula.

$$\text{Average wage rate } (yen/\text{h}) = \frac{532{,}057 yen/month\text{h}}{20 days \times 8\text{h}our}. \qquad (14)$$

The monthly income of Sapporo, which is 532,057 JPY, was divided by the average number of work hours per month. The average number of work hours per month was calculated by multiplying the average number of work days per month which is 20 by the number of work hours per day which is 8.

3.3 Discrete choice experiment: Partial profile choice experiment

3.3.1 Model framework

DCE theoretically builds on the Random utility model from McFadden (1974), the consumer theory of Lancaster (1966), and the DCE of Hanemann (1984).

First, the random utility model will be explained. The indirect utility function U_{ni} consists of observable deterministic term V_{ni} and unobservable random term ε_{ni}. The indirect utility function when respondent n selects alternative i is represented as

. (15)

Lancaster consumer theory is defined as

$$V_{ni} = \sum_{k=1}^{m} \beta_k X_i. \qquad (16)$$

V_{ni} is composed of a linear sum of m attribute vectors X_i. The Lancaster consumer theory is a theory that shows utilities for goods can be decomposed into separate utilities for their component characteristics or attributes (Lancaster, 1966).

Finally, the DCE (Hanemann, 1984) is the model of the probability that the respondent of n chooses i instead of j. The equation is represented as

$$P_{ni} = \Pr\,(V_{ni} + \varepsilon_{ni} > V_{nj} + \varepsilon_{nj}). \qquad (17)$$

The utility when selecting i is greater than the utility when selecting j. The DCE is based on the utility maximization theory that all human beings make decisions at the maximum level of utility.

4 Case study[1]: Understanding recreation demand

4.1 Introduction: Individual travel cost method

UGS play an important part in urban sustainability (Arnberger and Eder, 2012). UGS offer important recreation opportunities for urban dwellers under a hectic working environment (Hammitt, 2002; Pincetl and Gearin, 2005; Irvine et al., 2009; James et al., 2009; Haq, 2011; Badiu et al., 2016). While UGS provide the type of recreation unique to natural areas, such as the observation of animals and plants, they also offer high quality environmental settings for walking or running (Mitchell and Popham, 2008; Arnberger and Eder, 2012). To provide high-quality recreation continuously at UGS, it is essential to understand not only the UGS's recreation demand but also visitor characteristics (e.g., individual attributes, such as gender or motivations to visit such as walking or running). Failure to consider these properly can lead to excessive (or insufficient) facility renovation that is incompatible with the demand, or there may be a problem with economic efficiency in which the provided recreation conflicts with the recreation required by the visitor. In addition, since city areas tend to have multiple UGS, considering the spatial layout of UGS is essential to avoid creating equity-related issues, such as providing recreation only in particular areas.

The Sapporo city area, which is the study site, has been undergoing large renovation for UGS due to changes in the visitor groups at UGS and their aging facilities (City of Sapporo, 2017). Facility renovation for large UGS, which was performed in the past, aimed to provide standardized recreation opportunities. For example, facilities for children were set up in most of the large UGS. However, the problem of a low birthrate and an aging population is increasing in the Sapporo area (City of Sapporo, 2017), so there is a possibility that facility for children may not be

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[1] This chapter has already been submitted as research articles.

used as frequently. In addition, the number of people who walk or run has been increasing rapidly in recent years (Japan Sports Agency, 2019) because of the change in the awareness about maintaining their health. While a policymakers need to respond to such visitor group changes via renovation, UGS management must also consider financial sustainability.

Therefore, it has been discussed that large UGS in city areas should be categorized and that specific types of renovation should be performed, depending heavily on visitors' requirements (City of Sapporo, 2017). Large UGS are expected to provide various ES. However, understanding recreation demand alone cannot create a plan. Knowledge about recreation demand and visitor characteristics is vital for creating a renovation plan.

This study targeted 29 large UGS in the Sapporo city area, and aimed to understand recreation demands and visitor characteristics using the ITCM. Specific research questions were formulated as follows, expecting that they would contribute to renovation planning.

- How much benefit is generated from each type of UGS recreation, as valuated in the form of CS?
- How do individual attributes (gender, age, having small children, owning a car or having a driver's license) and motivations to visit (to walk, run, observe animals and/or plants, etc.) impact the number of visits to each UGS?
- What kind of implications can be obtained when interpreting CS valuations by taking the spatial layout of UGS into consideration?

4.2 Introduction: Kuhn-Tucker model

As noted above, due changes such as increase in health awareness and shift in demographics of the population, understanding UGS recreation demand and its relationship with individual attributes, motivations to visit and environmental attributes is indispensable in planning renovations. In addition, many of the improvements to environmental settings and facilities in the Sapporo city area occurred during or prior to the 1970s (City of Sapporo, 2017). There are some that did in fact stimulate UGS recreation demand and some that did not. In considering renovations, it is necessary to examine the appropriateness of the improvements made so far. For example, without understanding whether a fountain placed in the past stimulated UGS visits, the necessity of renovating the fountain when it is deteriorating cannot be determined.

Moreover, the demand for non-consumptive recreation is rising globally. The population of people engaging in forms of recreation such as walking, running, birdwatching, and so on, as well as expectations for the expansion of familiar UGS recreation sites are significantly increasing. However, as the price of land in urban areas is high, considerable costs are incurred in securing additional UGS. Thus, the recreation benefits produced through the expansion of UGS may not exceed the cost of expansion. If a recreation benefit that exceeds this cost is produced, then an examination of the expansion of UGS is merited. On the other hand, if recreation benefits do not exceed the cost, an examination of the expansion is not merited, even with low cost land such as in suburbs.

The primary purpose of this study is to construct large UGS demand model that targets 29 large UGS locations in the Sapporo city area using a KT model. From this, how individual attributes, motivations to visit and environmental attributes relate to visitor behavior will be understood. The secondary purpose is to examine the economic efficiency of expanding large UGS based on the demand model obtained. Specific research questions are as follows.

- Using a KT model, a demand model will be constructed from information on respondents' site choices and number of visits for the 29 large UGS, their individual attributes, motivations to visit and environmental attributes of the 29 large UGS. Through the process of constructing the demand model, whether individual attributes, motivations to visit and environmental attributes increase, decrease, or doesn't affect recreation demand will be understood.

  • In the demand model, UGS size is assumed to increase recreation demand. It is easy to see how larger numbers of visitors might be inclined to visit larger UGS. As the KT model can estimate benefits for an established scenario, the benefits that would be produced by increasing each large UGS by 1 hectare can be calculated. Through a comparison of this benefit with the price of land near each large UGS, the economic efficiency of increasing the size of each UGS can be determined. If the benefits obtained do not exceed the cost of purchasing the land, then expanding the UGS is not economically efficient. Also, the kind of location and conditions that lead to economic efficiency will be clarified. For example, a condition might specify that the conversion of expensive commercial land to UGS and does not merit consideration, whereas it is merited for suburban residential lands.

4.3 Method: Individual travel cost method

4.3.1 Survey design

Both the ITCM and KT models derived results from the same survey, but the survey design used in the analysis was slightly different due to their different purposes. ITCM survey was designed as follows. To answer the second research question, both individual attributes and motivations to visit were used in this study (Table 4). In the survey, motivations to visit were obtained by allowing respondents to provide multiple answers.

Table 4. Visitor characteristics used in Individual travel cost method and Kuhn-Tucker model

Visitor characteristics
Individual attributes
Gender
Age
Occupation
Income
Have small children
Own a car or have a driver's license
Motivations to visit
To walk
To walk with pet
To play with children
To take a picture
To use playground
To observe animals and/or plants
To do exercise (e.g., running, etc.)
To meet friends
To use a pool or splash pad
To admire the scenery
To participate in events
To play park golf
To read books
To use indoor facilities
To go camping
To spend time freely
To play sports (e.g., baseball, soccer, tennis)
To watch or support sports (e.g., baseball, soccer, tennis)
To take a rest or relax

4.3.2 Zero-inflated negative binomial model

In this study, information on the number of visits to 29 UGS is required. Usually, the number of visits can be grasped by conducting an onsite survey in each UGS. However, each UGS varies greatly in the number of visits and the number of visitors depending on various conditions such as weather and flowering conditions. For this reason, it is very difficult to obtain data from 29 UGS by controlling the bias of the onsite survey. Therefore, off-site survey approach that collects data on the visitors' number of visits to each UGS over a survey period was considered (Parsons, 2003).

The off-site survey approach is not often applied in practice due to the following reasons. First, many studies often focus only on one or a few recreation sites, which makes it possible to obtain data by conducting onsite surveys (Parsons, 2003). Under such situations, conducting off-site surveys would rather create more disadvantages. Also, it is often difficult to obtain enough data for the number of visits that can be used in statistical analyses. This occurs especially when target recreation sites are not widely known. Since the target recreation sites in this study are well-known large UGS in the Sapporo city area, it was possible to obtain data on the number of visits that can satisfy statistical analyses via off-site surveys.

Moreover, as described above, excess zeros will be included in data when using off-site surveys (Anderson, 2010). Including excess zeros in analysis can be a problem in estimating recreational benefits (Anderson, 2010). In an off-site survey, when a respondent answers the number of times they visit the site, the following two cases can be assumed. One case is the expected normal zeros wherein respondents normally visits UGS but they did not visit during the survey period. Since they are asked how many times they visited the target UGS during the survey period, it is also expected that they may answer zero visit to the sites. The second case is that the respondents are not considering visiting the target UGS at all. For example, respondents are not interested in outdoor recreation, thus they are not willing to visit the target UGS. In this case, the number of visits by the respondent is zero. This answer is the cause of the excess zeros. Since excess zeros can skew the results, the zero-inflated negative binomial model (ZINB model) was used in response.

4.3.3 Estimation model

The ZINB model assumes that the probability that the number of visits made by Respondent i becomes y_i can be explained by Negative binomial (NB) model in the second case by defining that the probability that the first case occurs is π while the probability that the other case occurs is $1 - \pi$ (Lambert, 1992; Greene, 1994).

$$\Pr(y_i = j) = \begin{cases} \pi_i + (1 - \pi) f(y_i = 0) & \text{if } j = 0 \\ (1 - \pi) f(y_i) & \text{if } j > 0 \end{cases}, \quad (18)$$

where π_i is defined by the logistic link function. $f(y_i)$ is obtained by the following negative binomial distribution.

$$f(y_i) = \Pr(Y = y_i) = \frac{\Gamma(y_i + \alpha^{-1})}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)} \left(\frac{1}{1 + \alpha\mu_i}\right)^{\alpha^{-1}} \left(\frac{\alpha\mu_i}{1 + \alpha\mu_i}\right)^{y_i}, \quad (19)$$

where μ_i denotes the number of visits made by respondent i while α expresses the estimated parameter. It is assumed that the number of visits μ_i can be expressed by travel cost p_i and visitor characteristics (i.e., individual attributes or motivations to visit) z_i.

$$\ln(\mu_i) = \alpha + \beta_p p_i + \beta_z z_i + \varepsilon_i \ , \quad (20)$$

where β_p and β_z are estimated parameters while ε_i shows an error term. The parameters can be estimated by the maximum likelihood method. Parameters that are both positive and statistically significant means that visitor characteristics can cause the number of visits to increase. On the other hand, parameters that are negative and statistically significant means visitor characteristics can cause the number of visits to decrease. Based on coefficient β_p for the travel cost estimated by this equation, it is possible to estimate the recreation benefit per person defined by CS as

$$\mathrm{CS} = -1/\beta_p. \qquad (21)$$

4.4 Method: Kuhn-Tucker model

4.4.1 Survey design

As individual attributes and motivations to visit used in this study are same as ITCM. Information regarding the environmental attributes of the UGS was collected from guidebooks and statistical information for each city in the area. For environmental attributes, variables were created and defined as dummy variables that expressed the presence or absence of art exhibition areas (museums), sports facilities, water recreation facilities, running courses, parking lots, places to view spring blossoms, places to view the night sky, fountains, large playing facilities for children, eating areas, and barbecue areas. Furthermore, continuous variables were defined for the number of events held in the UGS, area of the UGS, and area of forests in UGS. Attempts were made to identify the area of bodies of water, lawns, and other topological features from collected information and aerial photographs, but many of these were under tree cover, so no definite calculation of their area could be made. Thus, in the interest of reliability, only the area of forest was adopted. The information of environmental attributes used in this study was represented as follows (Table 5).

Table 5. Site characteristics used in Kuhn-Tucker model

Site characteristics
Environmental attributes
Whether or not art exhibition areas (museums) are provided
Whether or not sports facilities are provided
Whether or not water recreation facilities are provided
Whether or not running courses are provided
Whether or not parking lots are provided
Whether or not places to view spring blossoms are provided
Whether or not places to view the night sky are provided
Whether or not fountains are provided
Whether or not large playing facilities for children are provided
Whether or not eating areas are provided
Whether or not barbecue areas are provided
The number of envent held in the UGS
Area of the UGS
Area of forests in UGS

4.4.2 Estimation model

In the KT model, the utility function is often assumed to take an additively separable function form. Following von Haefen et al. (2004), the additively separable utility function is defined as

$$U = \sum\Psi(z, \varepsilon_j)\ln(\phi(q_j)x_j + \theta) + \frac{1}{\rho}z^{\rho}, \qquad (22)$$

$$\Psi(z, \varepsilon_j) = \exp(\delta' z + \varepsilon_j),$$

$$\phi(q_j) = \exp\,(\gamma' q_j),$$

$$\rho = 1 - \exp(\rho^*),$$

$$ln(\theta) = \theta^*$$

$$\ln(\mu) = \mu^*.$$

δ is the parameter vector for individual attributes and γ is the parameter vector for environmental attributes. Ψ includes individual attributes and motivations to visit and an error term, while ϕ includes the environmental attributes. ϕ is an index that compiles environmental attribute indicators into a single value, called a simple repackaging index. Under these settings, ϕ is necessarily positive. Additionally, as $\phi(q_j)x_j$, the environmental attributes of non-visited UGS $j(x_j = 0)$ are set so as to not affect the utility function (that is, weak complementarity is fulfilled). θ is called "translating" and indicates the portion that affects utility with no relation to number of visits. ρ expresses the income effect.

4.4.3 Welfare measure

Compensating variation with respect to changes in travel costs and environmental attributes are defined as below using the indirect utility function obtained from equation (4).

$$V(p^0, q^0, M, \beta, \varepsilon) = V(p^1, q^1, M - CV, \beta, \varepsilon). \qquad (23)$$

Additionally, it is defined as follows when the expenditure function is used.

$$CV = M - e(p^1, q^1, U^0(p^0, q^0, M, \beta, \varepsilon), \beta, \varepsilon). \qquad (24)$$

CV is $CV = (p^1, q^1, p^0, q^0, M, \beta, \varepsilon)$ and is a random variable since it includes the error term ε. Therefore, only the expected value of CV can be computed, which is denoted as $E(CV)$. In contrast, as the utility function takes a non-linear form in relation to income under the settings of this study, CV cannot be algebraically obtained. Therefore, a method that obtains it in an exploratory way using numerical methods such as the bisection approach is used. In this study, compensation surplus is estimated by adopting an approach that uses the first-order condition for utility maximization expressed in von Haefen et al. (2004). Please reference von Haefen et al. (2004) for the estimation procedure.

4.5 Results: Individual travel cost method

4.5.1 Data and descriptive statistics

The web-based survey was conducted in December 2017. The respondents were Sapporo city residents who are registered in the research company website. These respondents were sampled such that their age (from 20s to 60s) and gender were representative of the population at large in the Sapporo city area. The total number of respondents was 1,109. In ITCM, 14 respondents who did not report their address were removed from the dataset because in this case travel cost for their visits to the 29 UGS could not be estimated. Another 27 respondents whose number of visits of UGS is extremely large were also removed. Specifically, respondents who visited UGS for more than half of the 244 days of the survey period and respondents who visited a particular UGS more than once a week were excluded. Finally, 1,068 respondents were applied to analysis in this study.

Table 6 shows that descriptive statistics for the number of visits to 29 UGS in the Sapporo city area. First, the respondents were asked whether they know each 29 UGS or not. In the case of Odori park and Nakajima park, more than 1,000 respondents out of 1,068 answered that they knew the parks well. The third column shows that the number of respondents who visited each UGS during the no-winter seasons in 2017 (from April to November). The fourth column indicates that the total number of visits to each UGS. Odori park was visited by 760 visitors and the total number of visits exceeds 3,745. While, for each of the four least familiar UGS (i.e., Ryokuyo park, Aoba park, Hoshimi green space, Yamaguchi green space), less than 200 respondents answered that they knew the UGS. The mean number of visits was calculated by dividing the total number of visits by the number of respondents who knew each UGS. The mean number of visits to Odori park was at 3.55, far greater than those of other UGS.

Table 6. The number of visits to 29 urban green spaces in the Sapporo city area

Name	**Familiarity***	**Visitors****	**Total visits*****	**Mean visits† (s.d.)**
Odori park	1,054	760	3,745	3.55 (5.33)
Takino suzuran hillside park	926	150	266	0.29 (1.15)
Makomanai park	857	179	534	0.62 (2.50)
Maruyama park	998	368	978	0.98 (2.45)
Sapporo art park	914	155	263	0.29 (0.93)
Monami park	551	58	117	0.21 (0.85)
Nakajima park	1,004	355	1,022	1.02 (2.97)
Asahiyama memorial park	793	133	263	0.33 (1.20)
Toyohiragawa green space	654	115	405	0.62 (2.87)
Ishiyama green space	487	59	95	0.20 (0.75)
Nopporo forest park	890	122	271	0.30 (1.23)
Hiraoka park	751	148	312	0.42 (1.83)
Nishioka park	541	58	82	0.15 (0.52)
Tsukisamu park	649	109	219	0.34 (1.00)
Ishikari river riverbed green space	245	26	56	0.23 (0.81)
Atsubetsu park	426	48	126	0.30 (1.14)
Ryokuyo park	124	17	30	0.24 (0.73)
Moerenuma park	963	220	421	0.44 (1.23)
Sapporo satoland	880	169	317	0.36 (1.15)

Yurigahara park	840	149	384	0.46 (1.99)
Kawashimo park	480	81	199	0.41 (1.49)
Aoba park	136	21	40	0.29 (0.83)
Maeda forest park	694	106	229	0.33 (1.46)
Miyagaoka park	224	35	80	0.36 (1.33)
Gotenzan park	266	73	171	0.64 (2.16)
Teine inazumi park	492	46	161	0.33 (1.75)
Noushi park	623	98	256	0.41 (1.31)
Hoshimi green space	112	26	59	0.53 (1.31)
Yamaguchi green space	133	19	36	0.27 (0.85)

[*] The number of respondents who knew each urban green space (N = 1,068).

[**] The number of respondents who visited each urban green space during the 2017 no-winter seasons (from April to November).

[***] The total number of visits to each urban green space by respondents.

[†] The mean number of visits was calculated by dividing the total number of visits by the “familiarity”.

4.5.2 Parameter estimations

Table 7 shows coefficients of travel cost estimated from NB and ZINB models. These are necessary to calculate CS. Of the 29 large UGS, 8 UGS for which the travel cost coefficient was positive, and could not be statistically and significantly estimated by the ZINB model were not shown in the Table 7. Furthermore, for 4 of these UGS, it was not possible to obtain an appropriate estimation result even with the NB model. As shown in Table 6, number of visits for 8 UGS were not properly estimated in the ZINB model due to the insufficient number of samples. From this point on, 8 UGS will be excluded from the analysis.

The daggers on the coefficients of travel cost obtained by the ZINB model in Table 7 indicate results from the Wald test. These results examined whether the coefficients are statistically and significantly different from the NB models. For the ZINB model for the 21 UGS, the goodness-of-fit of the ZINB model was calculated in the same way as the likelihood ratio index based on the log-likelihood when estimated by the Poisson model. As a result, the model for the Toyohira green space was the largest and the goodness-of-fit was 0.459. The smallest was 0.073 for the model for the Ishiyama green space, and the others were at least 0.138. Therefore, although the results are shown, the estimation results for Ishiyama green space are not very reliable. As shown in Table 6, the number of visits to Ishiyama green space is equivalent to the 8 UGS which are excluded.

Table 7. The Negative binomial and Zero-inflated negative binomial models results

Name	**Negative binomial model**	**Zero-inflated negative binomial model**	**Consumer surplus estimated by ZINB (JPY)**
	Coefficient of travel cost parameters‡		
Odori park	–0.517 ***	–0.410 ***, †	8,553
Takino suzuran hillside park	–0.768 ***	–0.517 ***	482
Makomanai park	–1.700 ***	–1.219 ***, †††	410
Maruyama park	–1.184 ***	–0.652 ***, †††	1,404
Sapporo art park	–0.741 ***	–0.775 ***	318
Monami park	–1.819 ***	–1.163 ***, ††	94
Nakajima park	–0.877 ***	–0.340 ***, †††	2,814
Asahiyama memorial park	–0.965 ***	–1.089 ***	226
Toyohiragawa green space	–1.933 ***	–1.451 ***	261
Ishiyama green space	–1.530 ***	–1.380 ***	64
Nopporo forest park	–0.970 ***	–0.795 ***	319
Hiraoka park	–1.539 ***	–1.013 ***, †††	288
Nishioka park	–1.483 ***	–0.391	–
Tsukisamu park	–1.849 ***	–0.773 ***, †††	265
Ishikari river riverbed green space	0.215	0.095	–
Atsubetsu park	–1.152 ***	–0.053	–
Ryokuyo park	– ‡‡	– ‡‡	–
Moerenuma park	–1.048 ***	–0.571 ***, †††	690
Sapporo satoland	–1.227 ***	–0.208 ***, †††	1,427
Yurigahara park	–1.362 ***	–0.758 ***, †††	474
Kawashimo park	–1.875 ***	–1.034 ***, †††	180
Aoba park	–0.547	– ‡‡	–
Maeda forest park	–1.310 ***	–1.015 **, ††	211
Miyagaoka park	–1.671 ***	–0.505	–
Gotenzan park	–1.654 ***	–0.948 ***, †††	169

Teine inazumi park	–1.594 ***	–0.729	207
Noushi park	–2.686 ***	–1.331 ***, †††	180
Hoshimi green space	–1.781 ***	–‡‡	–
Yamaguchi green space	–1.297	–‡‡	–

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

†, ††, ††† Wald test of linear restrictions of negative binomial model (††† $p < 0.01$, †† $p < 0.05$, † $p < 0.10$).

‡ The travel cost measured in 1,000 JPY (1,000 JPY was equal to approximately 9.24 USD or 8.27 EUR on November 4, 2019).

‡‡ The parameters could not be estimated by the maximum likelihood method.

4.5.3 Estimating consumer surplus

Table 8 shows the CS estimated by the ZINB model obtained through equation (21). According to the results, Odori park’s CS was the highest at 8,553 JPY. Nakajima park, Sapporo satoland, and Maruyama park, followed with 2,814, 1,427, and 1,404 JPY respectively. On the other hand, Monami park and Ishiyama green space did not exceed 100 JPY. The lowest CS among all UGS was for Ishiyama green space at 64 JPY.

Table 8. The consumer surplus estimated by Zero-inflated negative binomial model

Name	Consumer Surplus estimated by ZINB
Odori park	8,553
Takino suzuran hillside park	482
Makomanai park	410
Maruyama park	1,404
Sapporo art park	318
Monami park	94
Nakajima park	2,814
Asahiyama memorial park	226
Toyohiragawa green space	261
Ishiyama green space	64
Nopporo forest park	319
Hiraoka park	288
Nishioka park	
Tsukisamu park	265
Ishikari river riverbed green space	
Atsubetsu park	
Ryokuyo park	
Moerenuma park	690
Sapporo satoland	1,427
Yurigahara park	474
Kawashimo park	180
Aoba park	
Maeda forest park	211
Miyagaoka park	
Gotenzan park	169
Teine inazumi park	207
Noushi park	180
Hoshimi green space	
Yamaguchi green space	

† The travel cost measured in 1,000 JPY. (1,000 JPY was equal to approximately 9.24 USD or 8.27 EUR on November 4, 2019).

Figure 6 shows the results of Table 8 on the map. The CS for each UGS during the survey period is represented by a bar graph. One bar represents 1,000 JPY. For example, CS of Odori park is 8,553 JPY. Thus, this is represented by 8 full bars and a half bar which represents the remaining CS.

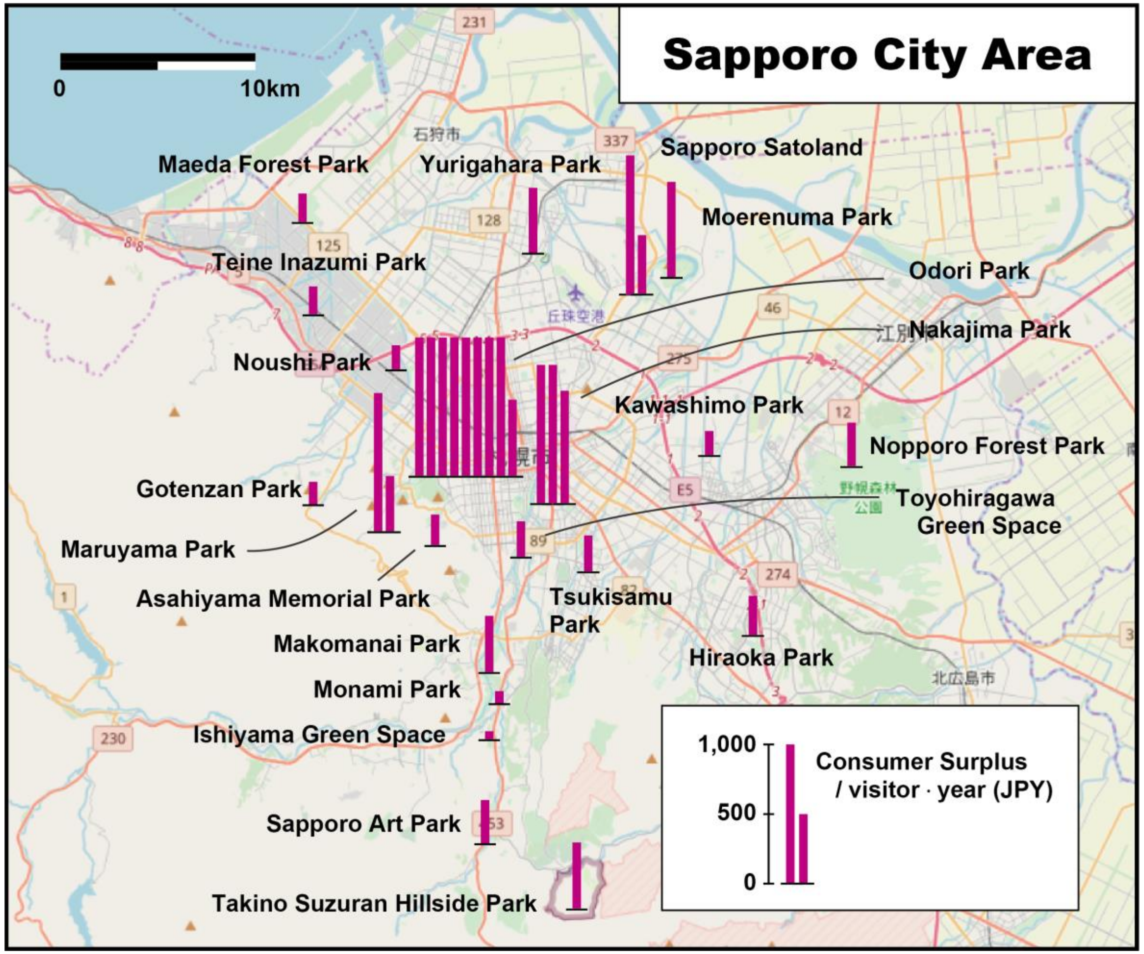

Figure 6. Locations of each urban green spaces and consumer surplus

Figure 7 combined the population heat map and the estimation results because population distribution helps in the interpretation of the amount of CS and plays a major role when considering the relationship between the spatial layout of the UGS and the CS. As can be seen in the result, there are some large UGS with high CS such as Odori park, Nakajima park, and Maruyama park in the central area of Sapporo city, where there is high population. On the other hand, some UGS in suburbs have the relatively high CS, although the surrounding population is not so large.

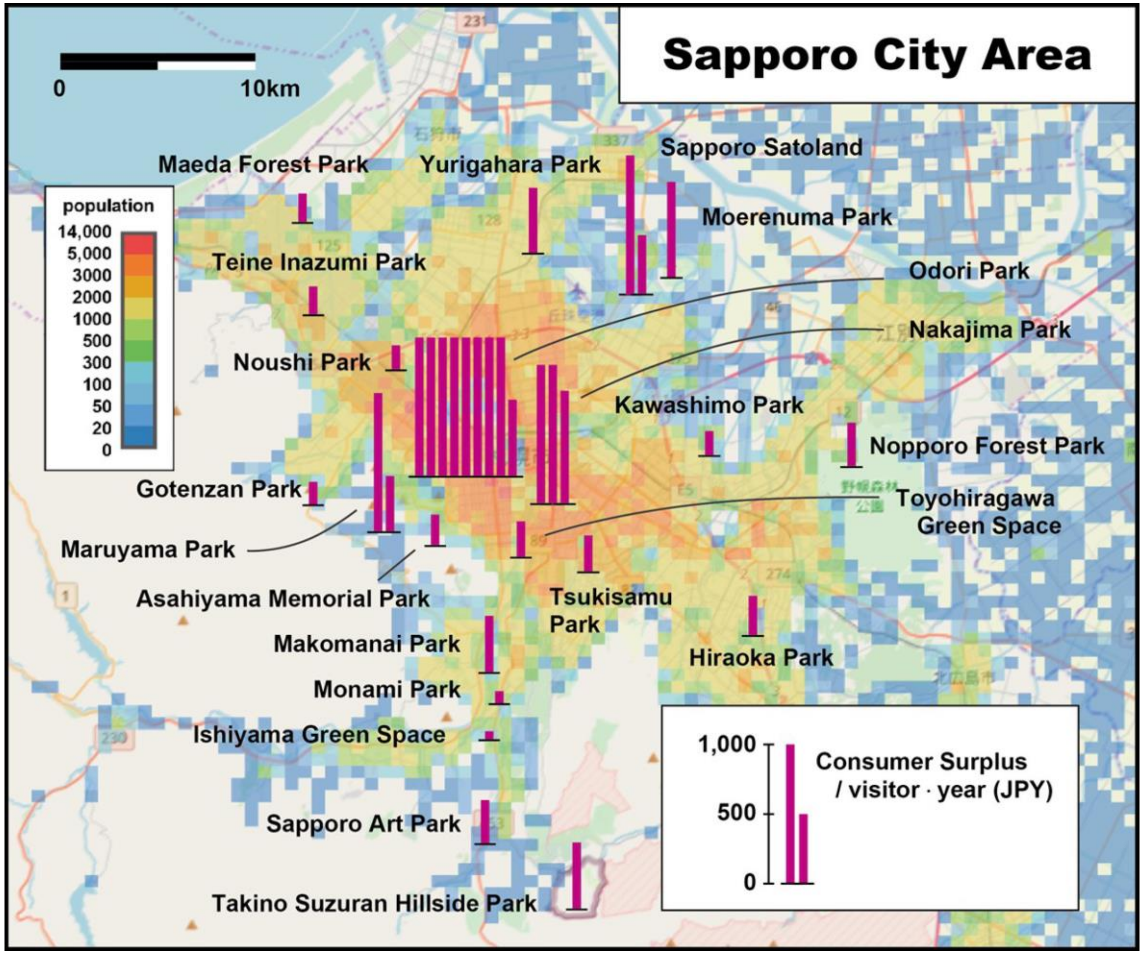

Figure 7. Population heat map and consumer surplus

4.5.4 Visitor characteristics

Table 9 represents coefficients of visitor characteristics, which impact the number of visits to each UGS. To consider the third research question, the results in Table 9 are overlaid on map data.

Table 9. Impacts of individual attributes and motivations to visit on the number of visits to each urban green space

Name	**Individual attributes**				**Motivations to visit**		
	Male	**Elderly**	**Children**	**Car**	**Walking**	**Running**	**Wildlife**
Odori park	0.143**				0.468***	0.521***	
Takino suzuran hillside park			0.665***	0.751***			0.869***
Makomanai park	0.387**		0.287**		0.656***	1.404***	
Maruyama park			0.270***		0.530***	0.489***	0.365**
Sapporo art park	–0.612***			0.743***	0.492**	1.417***	
Monami park			0.403**		0.500*	0.476*	
Nakajima park		0.116*	0.149***		0.346***	0.566***	0.534***
Asahiyama memorial park	0.666***		0.666***		1.319***	1,021***	1.141***
Toyohiragawa green space			0.562***		0.862***	1.503***	0.671*
Ishiyama green space			0.566**	1.003**	0.846**	0.792*	
Nopporo forest park		0.637**	0.668***	0.460**	0.666***	1.327***	0.920**
Hiraoka park	–0.333**	0.435**	0.408***	0.559***	0.278**	0.726***	
Nishioka park	–	–	–	–	–	–	–
Tsukisamu park		0.215*	0.437***	0.265**	0.285***		0.329*
Ishikari river riverbed green space	–	–	–	–	–	–	–
Atsubetsu park	–	–	–	–	–	–	–
Ryokuyo park	–	–	–	–	–	–	–
Moerenuma park		0.230**	0.500***	0.473***	0.242**	0.634***	0.301*

Sapporo satoland			0.217**	0.181**	0.123**	0.158*	
Yurigahara park		0.227**	0.433***	0.500***	0.502***	0.326*	0.394**
Kawashimo park			0.764***	0.485***			
Aoba park	–	–	–	–	–	–	–
Maeda forest park		0.512**		1.011***		0.654**	
Miyagaoka park	–	–	–	–	–	–	–
Gotenzan park		0.494***	0.671***			0.653**	
Teine inazumi park	0.297**		0.358***				0.319*
Noushi park			0.411***	0.388**	0.393***	0.339*	
Hoshimi green space	–	–	–	–	–	–	–
Yamaguchi green space	–	–	–	–	–	–	–

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

The following figures are the results of individual attributes that have a positive effect on the number of visits. The gender that positively affect the number of visits were overlaid on the Sapporo city map (Figure 8). As shown in the result, the places with high male visit rate were Teine inazumi park, Odori park, Asahiyama memorial park, and Makomanai park. Hiraoka park and Sapporo art park, on the other hand, are more likely to be visited by females than males.

Figure 9 shows the result of the elderly, which has a positive effect on the number of visits, overlaid on the Sapporo city map. As shown in the result, the elderly did not influence the number of visits to the majority of UGS. Considering that the elderly population differs by region, Figure 10 was made to show the overlay of population aging heat map and the estimation results of CS. However, the figure only shows the data for population aging heat map of the Sapporo city area since data for other areas were unobtainable. The figure shows that UGS located near areas with high population aging rates have significantly high number of visits from the elderly. For example, Yurigahara, Gotenzan, Moerenuma and Tsukisamu parks have significantly high number of elderly visitors. However, there are some UGS in areas with high aging rates that did not have a significant number of visits from the elderly.

Figure 11 is the overlay of the distribution of having small children over the Sapporo city map. It shows that having small children had a significant effect on the number of visits. Owning a car or having a driver’s license positively affects the number of visits to UGS in the suburbs. As shown as Figure 12, it had significantly high impact on the number of visits in 12 out of 21 UGS.

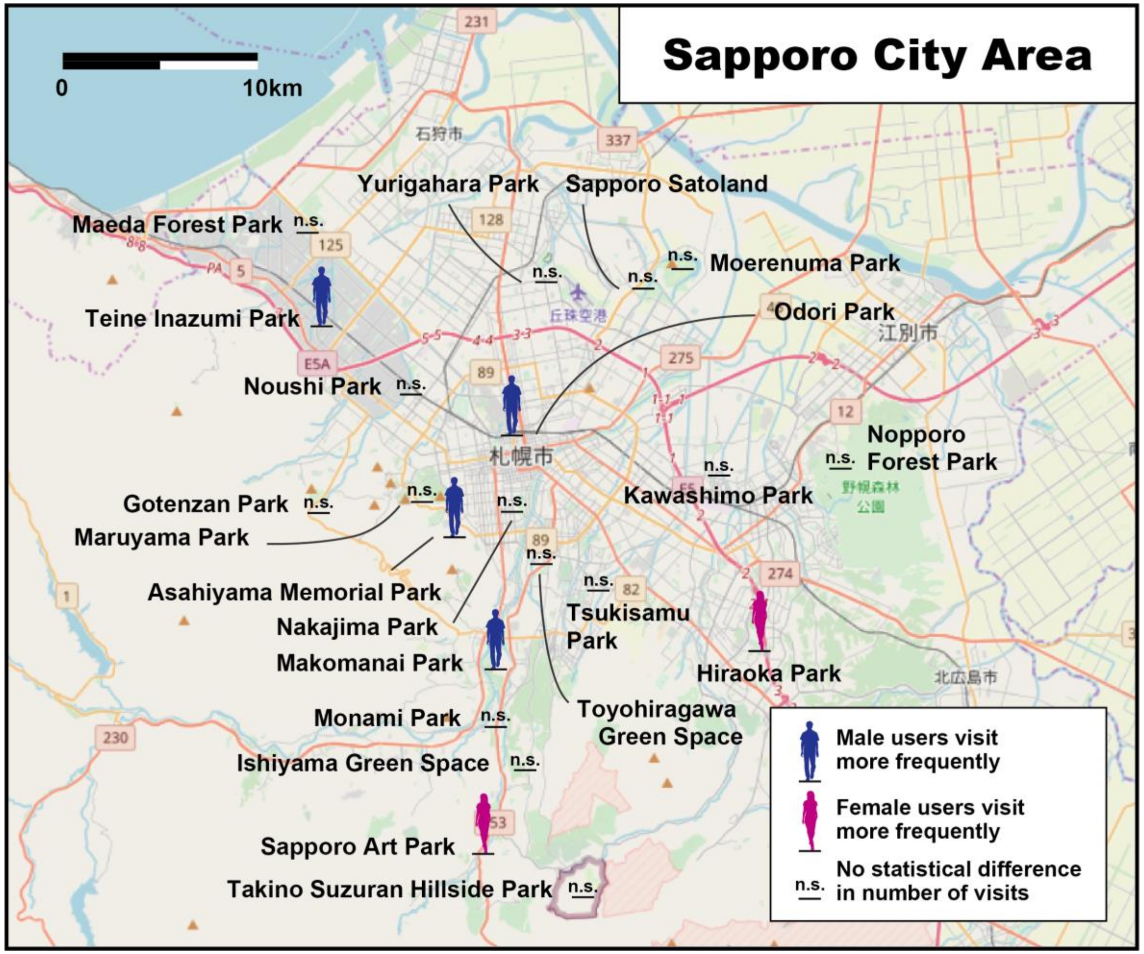

Figure 8. Distribution of the gender attribute that affects the number of visits

Figure 9. Distribution of the elderly attribute that affects the number of visits

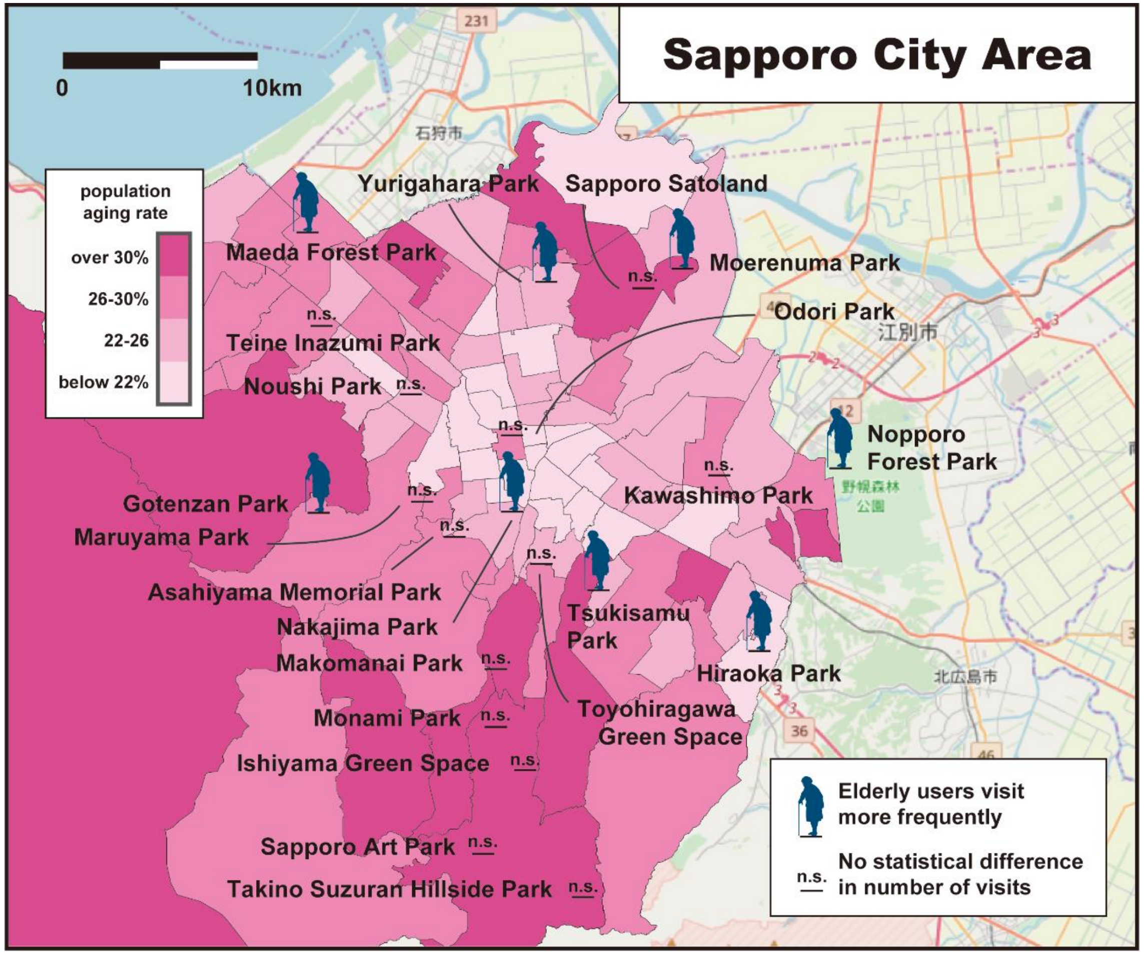

Figure 10. Overlay of population aging heat map and distribution of the elderly attribute that affects the number of visits

Figure 11. Distribution of having small children attibute that affects the number of visits

Figure 12. Distribution of attribute for owning a car or having driver's license that affect the number of visits

The following are the results of motivations to visit that have a positive effect on the number of visits. The variables for walking or running had significantly high impact on the number of visits in 18 out of 21 UGS (Figure 13). Variable for observing animals and/or plants had not influenced the number of visits to the majority of UGS (Figure 14).

Figure 13. Distribution of variables for walking or running that affect the number of visits

Figure 14. Distribution of variable for observing animals and/or plants that affect the number of visits

4.6 Results: Kuhn-Tucker model

4.6.1 Data and descriptive statistics

As information about income and travel cost is required in the KT model analysis, 35 respondents who lacked information about their income or residence were excluded from the analysis. Travel costs were calculated based on road distance from each of the target UGS to the residence of respondents, so residence addresses were required. In addition, 16 respondents, each with more than 130 visits during the period (indicating a visit to a UGS at least once every two days), and nine respondents who visited a specific UGS 35 times or more during the period (indicating a visit to a specific UGS once or more per week), were excluded from the analysis. Including these frequently-visiting respondents in the analysis would have a significant effect on the estimation results. Finally, 1,049 of the total 1,109 respondents were used in analysis.

4.6.2 Model estimates

Estimate results are shown in Table 10. Variables for individual attributes, motivations to visit and environmental attributes were included in the model if they exceeded the 5% level of significance, while all others were excluded from the estimates. Area of forest was excluded from the estimates as it correlated strongly with area of park.

Looking at Ψ, which includes individual attributes, gender had no effect on number of visits. With respect to age, respondents in their 40s and 50s were used as the control group for the dummy variables, with variables defined for those in their 20s and 30s as younger and those in their 60s as elderly as treatment groups. Both the younger and elderly age groups made more visits in comparison to those in their 40s and 50s. Respondents who chose walking, running, and observing animals and/or plants as a motivations to visit had a larger number of visits. Similarly, having small children and owning a car or having a driver's license also increased the number of visits.

With respect to environmental attributes, art exhibition areas, sports facilities, water recreation facilities, fountains, large playing facilities for children, eating areas, barbecue areas, and UGS area (logarithmic value) all contributed to a significant increase in the number of visits. When a model using a logarithmic value of UGS area was used, the coefficient was estimated to be statistically significant and positive. However, when a model using the value of area itself was used, the coefficient was not statistically significant. The coefficient for the Odori park dummy variable was also statistically significant with a relatively large value. The results may be said to be intuitively consistent with the exception of the sign of the dummy variable expressing the presence of lagre playing facilities for children.

Table 10. Parameter estimates using a Kuhn-Tucker model

Variables	Coefficient	s. e.	*t*-stat.
Scale parameter μ			
	−0.338 **	0.019	−18.166
Constant and individual attributes Ψ			
Constant	4.685 **	0.605	7.743
In 20s and 30s†	0.137 *	0.068	2.036
In 60s†	0.241 **	0.075	3.211
Motivation to visit is walking (yes =1, no =0)	0.437 **	0.058	7.487
Motivation to visit is running (yes =1, no =0)	0.343 **	0.103	3.323
Motivation to visit is observing plants and/or animals (yes =1, no =0)	0.335 **	0.091	3.673
Having small children (yes =1, no =0)	0.365 **	0.072	5.042
Owning a car or having a driver's license	0.356 **	0.074	4.791
Translating θ			
	2.162 **	0.081	26.844
Environmental attributes φ			
Whether or not art exhibition areas (museums) are provided (yes =1, no =0)	0.119 **	0.038	3.137
Whether or not sports facilities are provided (yes =1, no =0)	0.480 **	0.050	9.692
Whether or not water recreation facilities are provided (yes =1, no =0)	0.146 **	0.028	5.210
Whether or not fountains are provided (yes =1, no =0)	0.160 **	0.032	5.051
Whether or not large playing facilities for children are provided (yes =1, no =0)	−0.365 **	0.038	−9.554
Whether or not eating areas are provided (yes =1, no =0)	0.180 **	0.040	4.456
Whether or not barbecue areas are provided provided (yes =1, no =0)	0.267 **	0.041	6.537
Area of urban green space （ha・log value）	0.155 **	0.011	13.798
Odori park dummy variable	1.599 **	0.077	20.861
Income effect ρ			
	−2.512 **	0.495	−5.077

Log-likelihood	−12966.0

** $p < 0.01$, * $p < 0.05$

†Dummy variables taking those in their 40s and 50s as control group

4.6.3 Welfare analysis

The benefits of increasing each large UGS by 1 hectare of area are shown in Table 11. The estimate results show the average benefit per resident during non-winter seasons. Winter season benefits are not included. The benefit of increasing UGS by 1 hectare of area tends to be greater for larger UGS, which have a larger number of average visits. However, when the variable for area of UGS is a logarithmic value, the benefits from increasing the size of smaller UGS by 1 hectare tends to be relatively large compared to the benefits of increasing the size of larger UGS by one hectare. To confirm this trend, the percentage by which UGS size would increase if its current area was increased by one hectare is shown in Table 11. The average number of visits to Odori park is by far larger than any other UGS and it has a small area, so the benefit of increasing Odori park by one hectare is extremely large. In contrast, Nopporo forest park had the 10th largest number of visits of the 29 locations examined, but as it has a large area, the benefits of increasing this area by 1 hectare are extremely small.

Table 11. Welfare measure from increasing each large urban green space by 1 hectare

Name of urban green space	**Willingness-to-pay (value per person from a 1 hectare increase during the study period)**	**Percentage increase in park area from a 1 hectare increase**
Odori park	67.31	12.66%
Takino suzuran hillside park	0.27	0.25%
Makomanai park	0.67	1.18%
Maruyama park	1.70	1.46%
Sapporo art park	2.34	2.56%
Monami park	0.41	3.37%
Nakajima park	5.88	4.24%
Asahiyama memorial park	1.35	4.93%
Toyohiragawa green space	0.30	0.81%
Ishiyama green space	0.95	8.40%
Nopporo forest park	0.02	0.05%
Hiraoka park	0.42	1.51%
Nishioka park	0.17	2.44%
Tsukisamu park	0.59	4.59%
Ishikari river riverbed green space	0.13	6.90%
Atsubetsu park	0.98	7.58%
Ryokuyo park	0.28	2.09%
Moerenuma park	0.82	0.96%
Sapporo satoland	1.80	1.35%
Yurigahara park	1.77	3.94%
Kawashimo park	0.59	5.13%
Aoba park	0.02	7.63%
Maeda forest park	0.52	1.68%
Miyagaoka park	0.09	3.01%
Gotenzan park	0.31	4.07%
Teine inazumi park	0.69	5.49%
Noshi park	1.59	8.06%
Hoshimi green space	0.22	6.45%
Yamaguchi green space	0.09	2.25%

Table 12 shows the total benefit of increasing the area of large UGS, which are located in the city center and the southern part of the city, by 1 hectare (for the non-winter seasons). The average benefit per resident during the non-winter season obtained from increasing the area of UGS by one hectare is multiplied by the labor force of the Sapporo city area (1.45 million people) to calculate the total annual benefits. Furthermore, following Japanese project evaluation standards for public projects, the total benefits are calculated with a benefit estimation period of 40 years and a social discount rate of 4%. The subset in Table 12 includes UGS in the city center, the suburbs, and the intermediary space between these two areas; therefore, overall trends can be identified by understanding the benefits obtained from these representative UGS.

The declared value of land at the point of valuation closest to each UGS is also shown in Table 12 for comparison purposes. The declared value of land in Japan includes values of commercial land, residential land, and forested land that are periodically monitored. The actual trade value, or market price, typically differs from the declared value; however, because a wide variety of factors can affect market prices, the declared value is used. Generally, the market price tends to be higher than the declared value in the Sapporo city center. The price of forested land tends to be considerably cheaper than commercial or residential land. However, if forested land is bought to expand the size of UGS by 1 hectare, the area of recreational land in the UGS does not expand by one hectare; instead, the area of forest in the UGS expands by 1hectare. As a result, Table 12 shows the benefits based on the demand model from Table 3 that uses the logarithmic value of the area of the UGS as well as another set of benefits based on a demand model that uses the logarithmic value of the area of forest.

Table 12. The costs and benefits of expanding the respective areas of 10 different large urban green spaces by 1 hectare

		Cost (posted land price for 1 hectare)			Benefit (1 hectare increase)		Benefit / Cost		
Name of UGS	**Area***	**Commercial land**	**Residential land**	**Forested land**	**UGS area**	**Forested land**	**Commercial land**	**Residential land**	**Forested land**
Odori park	city center	12,900	–	–	2,012.4	–	0.16	0.12	–
Nakajima park	city center	2,800	1,500	–	175.8	–	0.06	0.02	–
Maruyama park	city center	3,450	2,870	–	50.8	–	0.01	0.05	–
Asahiyama memorial park	interm ediate	–	829	–	40.4	–	–	0.01	–
Toyohiragawa green space	interm ediate	–	1,190	–	9.0	–	–	0.02	–
Makomanai park	interm ediate	–	822	–	20.0	–	–	0.03	–
Monami park	interm ediate	–	373	–	12.3	–	–	0.12	–
Ishiyama green space	interm ediate	–	228	–	28.4	–	–	0.38	–
Sapporo art park	suburb	–	183	2.9	70.0	84.6	–	0.04	29.17

Takino suzuran hillside park	suburb	–	183	2.9	8.1	9.6	–	0.12	3.31

* The city center is primarily commercial land, suburbs are near the boundaries of the Sapporo city area, and intermediate areas, which are mostly residential areas, are between the city center and the suburbs.

4.7 Discussion: Individual travel cost method

First, the overall estimation results obtained by the ZINB model will be discussed briefly. The coefficients of travel cost estimated by the ZINB model are smaller or equal compared to those obtained by the NB model. Applying a NB regression model to data containing excess of zeros that have a small mean of observation can lead to an increase in the absolute value of the estimated regression coefficient (Minami et al., 2007). In this sense, this result is a consistent result. For example, the coefficient of travel cost for Nakajima park shows that the coefficient from NB model was –0.877 and the coefficient from ZINB model was –0.340. This means that the CS from ZINB model, which is estimated from the equation (21), would have been valuated twice as low if the impact of excess zeros were not taken into consideration. On the other hand, there are also 8 UGS with the same results as those obtained from the NB models. The purpose of this study is not to discuss about characteristics of the ZINB model, but it is important to mention that the ZINB model is not always valid for off-site sampling data and the results are almost the same as the NB model depending on the distribution of visits to each UGS.

4.7.1 Recreation demands

Odori park has particularly large CS, followed by Nakajima park, and Maruyama park. The CS shown in Table 8 represent the estimated amount per person in no-winter seasons. Hence, the estimate of overall annual CS experienced by the visitors in this study is computed by multiplying the estimated CS per person by 1,068 respondents. As a result, it was found that the CS, and thus recreation benefits, of about 8.93 million JPY were generated annually in the entire Sapporo city area. Considering the total population of Sapporo residents aged between 20 to 69 years old (about 1.28 million), the annual benefit of the 21 large UGS exceeds 10 billion JPY.

However, the annual benefit is believed to be overestimated. Odori park hosts events including large seasonal events (e.g., beer garden and autumn fest) almost every month. Nakajima park and Maruyama park also hold large festivals and provide cherry blossom viewing opportunities. Furthermore, a concert hall is established next to Nakajima park while Maruyama park is connected to Hokkaido shrine and Maruyama zoo. This means that it is very likely that the value of attending various events and using facilities may be reflected on the CS for these UGS. Moreover, it is also necessary to consider that these three UGS are located in the center of the city. For example, when respondents passed through Odori park after work, they probably count it as part of their visit to the park on the survey. However, the visit is counted as visiting the park from home which causes the overestimated value.

On the other hand, combining the CS values and the population heat map (Figure 7) shows that the CS of the UGS located in the central area is linked to the population to some extent. If the UGS is nearby, the travel cost is small and the number of visits is increased, so the CS tends to be larger. In contrast, there are UGS in the suburbs with the relatively high CS even though not many live in the surrounding areas. Sapporo satoland, Moerenuma park, Yurigahara park, and Takino suzuran hillside park fall into that category. There are almost no people residing in the surrounding areas of Takino suzuran hillside park. This suggests that these UGS draw visitors from places other than the surrounding areas because of the attractiveness created by each park. For example, Sapporo satoland offers an agricultural experience program, which is believed to draw many visitors from places other than the surrounding areas.

4.7.2 Visitor characteristics

The impact of the gender attribute on the number of visits was apparent in some UGS, but there were no significant differences when focusing on the entire area in general. The reason why gender made a significant difference is obvious in some of the UGS while it is not the case for the other UGS. For example, more females get into art related fields in Japan (e.g., females account for about 70% of those who pass examinations to enter art colleges), which may explain the popularity of Sapporo art park. In addition, Hiraoka park is also famous for its plum-blossom viewing, which is also popular with women.

As to the elderly attribute, it is possible to explain to some extent how the elderly age group affects the number of visits to the UGS by looking at the overlay of the estimation results and the population aging heat map (Figure 10). UGS located in or near areas where many elderly live are actually visited a lot by elderly people. Yurigahara park and Nopporo forest park are examples of such cases, wherein their adjacent area have aging rates over 30% and 26‒30% rates, respectively. On the other hand, some cases cannot be explained by looking at the overlay of the estimation results and population aging heat map; in other words, there are some UGS that are not often visited by elderly even though these UGS are located in the areas where many of the elderly live. In particular, UGS located in the southern part of the area fall into that category.

The attribute of having small children in families was also affected the number of visits to the majority of UGS. This suggests that it is premature to conclude that due to the lower number of children, declining birthrate, and increased aging population, the large UGS are no longer used by children as often or that they are not as essential to the families with children who are small child and/or children. It can be argued that large UGS are still essential places to the families with small children (Burgess et al., 1988).

Another characteristic that affects the number of visits to UGS is the attribute of owning a car or having a driver’s license. People rely on their cars to visit UGS in the suburbs. However, this trend is also evident when people visit the UGS located very close to the central part of the city. Tsukisamu park and Noushi park fall into that category. Both parks have parking space shortage issues. Tsukisamu park, in particular, constantly has people waiting in line to get a parking space on the weekends during the no-winter seasons. With this in mind, the current situation and results obtained from this study correspond to one another. It is impossible to have a large parking area available at all UGS. Therefore, it may become necessary to consider classifying types for renovation, such as whether or not a UGS has more need for parking availability by anticipating what form of transportation people often use to visit the UGS.

Walking or running as motivations to visit were as impactful to the number of visits to the UGS as the attribute of having small children in families. The number of visits was increased by the walking or running attributes for majority of UGS. Facility maintenance for walking or running will be important not only from the standpoint of individual recreation use but also public health involving health maintenance and reductions in social security expenses (Bedimo-Rung et al., 2005; Blanck et al., 2012).

Observing animals and/or plants as a motivation for visit also increased the number of visits to the UGS. However, it is important to note that the type of UGS with increased number of visits for this reason is polarized into the UGS with a lot of greenery in the central part of the city such as Nakajima park and Maruyama park. This trend is also prevalent in UGS with plenty of sites to observe animals and/or plants in the suburb such as Yurigahara park and Takino suzuran hillside park with their famous gardens, and Nopporo forest park with its large forest and wild bird watching site (Hokkaido government, 2019; Sapporo Yurigahara Park, 2019; Takino Suzuran Hillside Park, 2019). While providing recreation opportunities to observe animals and/or plants is one of the most important roles played by UGS, it may be better to concentrate that role at specific UGS in the central area and suburbs rather than providing it at every UGS.

Based on the results of visitor characteristics, there are two very important points to keep in mind. First, UGS being in areas where aging population is becoming more apparent doesn’t necessarily mean people in the elderly visit those UGS more. Second, the level of need for UGS has not gone down for the families with small children. It is an urgent task to renovate the UGS in a way to respond to the lower birthrate and aging population. However, it does not necessarily mean that renovating a large UGS for the elderly in the area where the aging rate is high or reducing the availability of playing facilities for children just because of declining birthrate should be pursued.

4.7.3 Spatial layout

Examining the spatial layout of the UGS and the level of CS (Figure 6) shows that UGS with relatively high CS are often close to one another. For example, three large UGS in the north—Yurigahara park, Sapporo satoland, and Moerenuma park and two large UGS in the south—Sapporo art park and Takino suzuran hillside park fall into that example. Deciding where to build a UGS is also closely linked to the history of land use (Byrne and Wolch, 2009; Byrne, 2012;). Therefore, it is evident that a UGS cannot be established anywhere freely. Nevertheless, the fact that the large UGS in the suburbs representing the city of Sapporo are concentrated in a certain area means that the city plan of Sapporo did not take the spatial layout into consideration. Additionally, it should be emphasized that the UGS in both cases are not built and managed by one management entity. Among the first three large UGS, Sapporo satoland is considered an agricultural experience and exchange facility from the administrative perspective and managed by the Agricultural administration office of Sapporo city. Out of the latter two large UGS, Takino suzuran hillside park is a national government park, which is managed by the Ministry of land, infrastructure, transport and tourism, not by the park management office of Sapporo city. It was impossible to confirm how adjustments were made between the relevant departments when installing these large UGS. However, it was necessary to adjust according to the spatial layout of UGS regardless of the hierarchical relationship of the administrative agencies in charge.

Moreover, examining the spatial layout of the large UGS and higher CS shows that there are only a few large UGS in the northwestern part of the area. Yurigahara park, Sapporo satoland, and Moerenuma park are located in the northeastern part of the area. Nopporo forest park and Hiraoka park are found in the southeastern part of the area. Sapporo art park and Takino suzuran hillside park are located in the southern part of the area. Large UGS, such as the ones found in the suburbs do not exist in the west part of the area because of the mountainous region is in the area. Instead, parks, such as Maruyama park are located nearby the central area. Additionally, not only are there a few large UGS with higher CS in the northwestern part of the area, the area is also far away from the other large UGS with higher CS located in other areas. While large UGS are not found in some areas of the northern and northeastern parts of the city center, the residents in these areas still have quick access to Yurigahara park and Sapporo satoland in the suburbs and Odori park and Nakajima park in the central part of the city. Since the land in the Sapporo city area has already been developed, it is probably difficult to build the same type of large UGS in this area. However, it is important to keep in mind that there is a lack of fairness because there are not many large UGS with higher CS in northwestern area. At least, it may be necessary to give the area priority for facility maintenance involving renovation or consider allocating higher budget to build large UGS in the area.

4.8 Discussion: Kuhn-Tucker model

4.8.1 Individual attributes and motivations to visit and environmental attributes

As mentioned previously, the population of people who go walking or running in Japan has greatly increased in recent years. As a reflection of this situation, the results of this study show that the number of visits with walking or running as a visit motivation was, in fact, large. Observing animals and/or plants is another motivation associated with a large number of visits. These were the only variables with statistically significant coefficients, even though dummy variables such as relaxation and event participation were introduced. When making renovations, improvements to environmental settings and facilities in response to these three motivations to visit merit consideration.

Additionally, considering the effects of a low birthrate and aging population, the possibility of shifting UGS facility improvements from those aimed at children to those aimed at the elderly is examined. However, the estimate results showed that both visitors with children and the elderly have a high number of visits; in fact, the size of the coefficient indicates that visitors with children have a larger number of visits than the elderly. While the total number of visits from visitors with children may decrease in the future if birthrate and aging trends continue, it cannot be concluded that expectations regarding UGS facilities for children are presently declining. Chapter 5 used UGS in the Sapporo city area to estimate WTP with respect to facility improvements for facilities aimed at children and those aimed at the elderly by means of a choice experiment. In these results as well, improvements to facilities aimed at children were valued more highly than those aimed at the elderly. Based on these findings, shifting facility improvements to focus on elderly visitors is not considered appropriate.

Many of the environmental attributes increased the number of visits. Art exhibition area (museums), sports facilities, water recreation facilities, fountains, eating areas, barbecue areas, and the logarithmic value of the UGS area significantly increased the number of visits. Overall, it would be appropriate to say that facility improvements made to date have largely stimulated UGS recreation demand. Of course, it is not necessarily preferable to update the same facilities during renovations simply because the facility improvements made thus far have been appropriate. Renovations should be comprehensively planned in a way that also incorporates design. For example, an old fountain should not simply be updated to a new fountain in the same location. The results obtained in this study indicate that facility improvements described previously increased the number of UGS visits, that is, each of these facilities has actual visitors. As a result, for example, the decision not to update a fountain during renovations requires careful consensus building based on an understanding of the actual state of the fountain's use.

In contrast, the presence of large playing facilities for children significantly decreased the number of visits. This result was unexpected. As the absolute value of both the coefficient within the environmental attributes and the t-statistics were relatively large, this factor has a comparatively large effect. For the interpretation of this result, Tsukisamu park, where a large playing facility for children has been newly installed, is examined. The number of families visiting Tsukisamu park has significantly increased. The parking lot fills up quickly on holidays and a long line of waiting cars forms. Because large UGS visitors tend to come by car, visitors who have no use for a large playing facility for children may have begun to avoid using Tsukisamu park because of the crowded parking lot. As respondents with a small child and/or children are only one portion of the overall respondents, it seems that the presence of a large playing facility for children may significantly decrease the number of visits overall. If large playing facilities for children are introduced during renovations, consideration for visitors without children, for example, securing adequate parking for such visitors, may be necessary. Careful consideration is required, not only with respect to large playing facilities for children, but also for facility improvements for other visitors.

4.8.2 The economic efficiency of expanding urban green spaces

In this section, in order to prevent the discussion from becoming ovely complicated, the costs of expanding UGS are considered to be the costs of purchasing the land alone, and the benefits to be only those benefits obtained by expanding UGS by 1 hectare. This simplification is necessary because if facility improvements are to be built in the expanded UGS, then the cost of these improvements and the benefits produced by them would have to be taken into consideration.

As clearly shown from the cost-benefit ratios in Table 12, it is not economically efficient to purchase commercial or residential land to expand UGS. Odori park, located in the city center, is very small in size but has a very large number of visitors, so the benefits of expanding this park by one hectare are considerably larger than the benefits of expanding other parks. The total benefit is JPY 2,012 million, an extremely large amount. However, as the cost of land is even greater than this, the expansion of UGS is not economically efficient in this case. With respect to the 29 target UGS, including those large UGS not shown in Table 12, there are no cases in which the total benefits exceed the cost of either commercial or residential land. The cost-benefit ratio, which is 0.16 even at its largest in the city center at Odori Park, and 0.38 at its largest in the suburbs at Sapporo art park, means that purchasing commercial or residential land to expand UGS does not merit consideration.

In contrast, it is clear that converting forested land that are not commercial or residential to expand UGS is economically efficient. As the cost-benefit ratios shown in Table 12 indicate, it is very effective to expand the areas of smaller UGS, like Sapporo art park, through the acquisition of forested land, and even expanding large-scale UGS such as Takino suzuran hillside park is still economically efficient. However, in this case, a 1 hectare expansion is on the scale of approximately JPY 400,000 in annual benefits for 2.18 million city residents; although it may be economically efficient, the average resident may not be fully aware of such a small expansion. If a sizeable area of forested land exists in the suburbs and is located such that it can be integrated into Sapporo art park or Takino suzuran hillside park, such expansions would merit consideration. In contrast, in the city center or the intermediate area that lies between the city center and the suburbs, almost no sizeable areas of forested land exist. In places such as this, there is also no evaluation point for appraising the declared value of nearby forested land. However, even if forested land did exist in the city center or the intermediate area, such land would hold the potential value to be converted into residential or commercial land, making it economically inefficient to purchase such land for the expansion of UGS.

5 Case study[2]: Understanding benefit from ecosystem services and facilities

5.1 Introduction

Through ITCM and KT model, the benefit of recreation can be identified. TCM can only calculate use values and cannot calculate any type of non-use value (Martinez-Espineira and Amoako-Tuffour, 2008). Therefore, the results from TCM can only be considered as a lower-bound measure of the full benefit of recreational sites (Martinez-Espineira and Amoako-Tuffour, 2008). However, when valuating the benefit of UGS, it is important to identify the non-use value as well as the use value.

In the case of non-use value, it is often difficult to base calculations on visit data. For example, suppose the aim is to determine the benefit for providing an evacuation site. It is hard to get data unless there is a real earthquake. Thus, it is easier to set up a hypothetical situation and grasp it through a questionnaire, using suitable methods such as PPCE.

In order to increase the satisfaction of urban dwellers, it is necessary to prepare policies. In order to develop a policy, urban dwellers' demands for SEF should be identified. For this reason, it is necessary to understand whether SEF are being properly provided through the provision of UGS in accordance with the demands of citizens.

In Sapporo city, there are three issues that policymakers need to consider in a renovation plan, namely, the diverse demands of ES (e.g., habitats for wildlife), the new services never before required in UGS (e.g., as evacuation sites), and the change in the current user structure of UGS (e.g., declining birthrate). These issues greatly

[2] This section has already been published as a research article (Kim et al., 2020).

affect the demands of citizens regarding the ES provided by the UGS. However, policymakers of UGS have little awareness of the contemporary preferences for SEF. In order to establish policy, the overall demands of users for diverse services need to be understood (Doherty et al., 2014). This also applies to the demands of users in the Sapporo city area.

To valuate SEF, DCE is usually the preferred method (e.g., to valuate marine and forest ES). However, as human cognitive capacity is limited, respondents may face difficulty with a large number of attributes in each choice situation (Miller, 1956; Cowan, 2001). In the literature on DCE questionnaire design in the field of environmental valuation, it is especially recommended that the number of attributes be kept to a minimum (Holmes and Adamowicz, 2003). Bateman et al. (2002) recommended that the number be restricted to four to six. Instead, PPCE, which is a type of DCE, can applied to address this limitation (Chrzan, 2010). In this study, there are 15 attributes to be assessed, therefore, PPCE method was applied.

The aim of this study is to investigate the general public's benefit from SEF provided by UGS using PPCE. Specific research questions are as follows.

- There is no known existing case study that assesses environmental values using PPCE except Shoji et al. (2018). Thus, the applicability of PPCE as an environmental valuation method is set as major concern of this study. Using PPCE to determine whether respondents are able to properly understand the choice situation, the focus was on whether the provided SEF and their corresponding WTP are intuitively consistent. Through this, it is possible to assess whether or not PPCE model is sufficient when compared with conventional DCE studies.
- Policymakers of the Sapporo city area are considering whether to focus on facilities for the children or the elderly. For example, in the Sapporo city area, the development of facilities for the elderly are considered instead of playgrounds for children. Also, they are considering about whether the existing evacuation areas in

the event of disaster are sufficient. Therefore, these three issues will be discussed in this study. The findings may also be helpful to countries facing similar problems as mentioned above.

- Policymakers have also attempted to increase forest areas for recreation in urban areas (e.g., City of Sapporo, 2018). However, the public's demand for increasing forest areas is unknown. In addition, public demand may also be focused towards other SEF such as biodiversity. Therefore, it is necessary to understand the general public's demand on whether to keep the policy for increasing the forest area for recreation, while taking into consideration the demand for other SEF.

5.2 Method

5.2.1 Survey design

In this study, the PPCE task asked respondents to select the UGS management plan that they prefer from a set of alternative scenarios for SEF. A hypothetical management scenario was assumed to either strengthen or weaken 15 SEF currently provided by 29 UGS in the Sapporo city area.

First, the attributes included in the alternative UGS management plan had to be identified. ES were based on the The Economics of Ecosystems and Biodiversity report (The Economics of Ecosystems and Biodiversity, 2010). The Economics of Ecosystems and Biodiversity report (2010) identified 4 categories of ES, namely, provisioning services, regulating services, habitat or supporting services, and cultural services. Because most of the ES in this study are based on these categories, they are assumed to be qualified to be included in The Economics of Ecosystems and Biodiversity report. Next, to identify services provided by facilities, the management policy for UGS in Sapporo city (City of Sapporo, 2017) was reviewed and interview with experts were done (e.g., a council member for urban planning in Sapporo city). In addition to the services mentioned in The Economics of Ecosystems and Biodiversity report, the management policy for UGS defined 4 other services. These services are "Forming the landscape," "Providing facilities for children," "Providing places for learning," and "Providing a place for community activities." The services provided by facilities mentioned above were also identified by referring to expert interviews (e.g., "Providing facilities for the elderly," "Providing a place for events," "Providing evacuation sites," "Providing parking lots," etc.). The expected SEF were made based on the Sapporo city management policy for UGS and interview with experts.

A total of 15 attributes were determined as shown in Table 13. Attributes not usually expected in UGS, such as provisioning services (e.g., providing timber) were excluded. In addition, attributes expected for the larger land scale (e.g., moderation of extreme event) were excluded since the tax burden for the UGS management plan in Sapporo city had to be taken into account in the scenario. Furthermore, given the respondents are members of the general public, more familiar SEF were adopted, and fewer unfamiliar ES (e.g., carbon sequestration and air quality regulation) were excluded. The reason for this is that the unfamiliar ES would require respondents to have specialized knowledge of ecological processes (e.g., photosynthesis, gas exchanges at leaf surface) and their impact on human well-being. (Kumar and Kumar, 2008). On the other hand, the local benefits of cultural ES can be perceived or experienced by anyone, regardless of specialized ecological knowledge or measuring equipment (Andersson, 2015). Despite the lack of an official or clear definition of cultural ES, the adopted ES in the management policy for UGS in Sapporo city (City of Sapporo, 2017) and the interviews with experts conform to these. It should be noted that while "Providing parking lots" (No. 9) is clearly not a service provided by UGS, a lack of parking facilities is a major problem for UGS management in the study site.

Table 13. Ecosystem services and services provided by facilities for valuation

Services from ecosystem and facilities (SEF)
1. Forming the landscape Organize the town and form the landscape and scenery
2. Conserving biodiversity Habitat for wild animals and/or plants and conservation of biodiversity
3. Providing places to interact with the forest Forest and trees for viewing and walking
4. Providing lawns A lawn on which to relax or move physically
5. Providing places of interest with flowers Plants to enjoy flowers and autumn colors
6. Providing facilities for children Outdoor or indoor playing facilities mainly for children
7. Providing facilities for the elderly Park golf courses and health promotion facilities mainly for seniors
8. Providing cultural facilities Cultural facilities such as museums and art galleries
9. Providing parking lots Parking lots for visiting parks and green spaces by car
10. Providing playgrounds Sports facilities such as baseball, soccer, tennis, and athletics
11. Providing places for learning A place for learning opportunities such as nature experience, environmental education, gardening
12. Providing a place for events A place to hold events such as music events and/or marathons
13. Providing a place for community activities Interaction between local residents or a venue for volunteer activities
14. Providing eating areas Barbecues or meals prepared using an open fire
15. Providing evacuation sites Prevent fire from spreading and provide evacuation points in case of disaster

5.2.2 Profile design

In a choice set, there are six attributes of SEF and four alternative UGS management plans (profiles). Each attribute is assigned 1 of 4 levels based on the current area of UGS: a 25% decrease, 0% change (maintain status quo), a 25% increase, and a 50% increase. Adopting the percent of change in UGS area as a common unit was due to consideration of the limit of human cognitive capacity. If all 15 attributes were expressed in different units, it would be considerably taxing for respondents, considering each choice set in PPCE would have different set of attributes. A common unit also makes comparison easier between 15 SEF.

The tax attribute is also included as a cost to realize the hypothetical UGS management plan. The tax attribute was also assigned four levels like 500, 1,000, 2,000, and 5,000 JPY (100 JPY: 0.91 USD or 0.82 EUR on December 13, 2019), which were set based on the results of a previous research on forest ES (Shoji et al., 2018). Since the budget for current UGS management in the study area is covered by annual municipal taxes, the tax attribute's levels are set to be at the yearly rate. Additionally, the tax payment period was set to 10 years in consideration of the required time to realize the hypothetical UGS management plan. As shown in Figure 15, each alternative UGS management plan in a choice set involves a subset 5 SEF attributes chosen from 15 SEF, along with different tax attribute levels. The 5 SEF attributes included in the subset changes with each choice set.

	Plan 1	Plan 2	Plan 3	No Action
Forming the landscape	+25%	+25%	±0%	±0%
Conserving biodiversity	–25%	+25%	±0%	
Providing places to interact with the forest	–25%	+50%	–25%	
Providing facilities for children	+25%	+25%	+50%	
Providing facilities for the elderly	±0%	±0%	+25%	
Tax payment	1,000JPY	5,000JPY	2,000JPY	0JPY
Choose **ONE** preferred profile	○	○	○	○

Figure 15. A sample choice set

After the attributes and levels are determined, the profiles and choice sets have to be organized in an efficient way. In DCE, the orthogonal and efficient D-efficient designs are often used. However, in PPCE, these designs are too complex to be applicable. Thus, the profiles were designed through a randomized design using the SSI web (Sawtooth Software). Although one disadvantage of the randomized design is that it is not statistically efficient, this study addressed it by securing enough responses. A choice set, as shown in Figure 15, is then organized and a series of choice sets are composed by combining 8 different choice sets, resulting in the preparation of 50 different series of choice tasks. One of 50 different series of choice tasks is presented to a respondent, and the respondent is asked to complete 8 choice tasks included in the series of choice tasks

5.2.3 Method selection validity and description

PPCE is an application of conventional the DCE initially developed by Louviere and Hensher (1982), and Louviere and Woodworth (1983). The DCE method involves respondents choosing from hypothetical alternatives presented in choice sets described by levels of a set of attributes. By assessing the underlying trade-off from the respondents' choices, researchers can understand the trade-off between different attributes and their levels. This makes DCE a practical tool in the fields of marketing, transportation, health care, and environmental valuation (Mangham and Hanson 2008; Ryan et al., 2008; van Empel et al., 2011; Hoyos et al., 2012). More particularly, various ES (e.g., marine and forest ES) have been valuated in the environmental valuation literature (Juutinen et al., 2011; Can and Alp, 2012; Metcalfe et al., 2012; Stithou et al., 2012; Oleson et al., 2015). For example, Juutinen et al. (2011) valuated the biodiversity and recreational services provided by a national park in Finland and discussed trade-offs in the context of park development.

One problem with conventional DCE is that the number of attributes it can valuate is limited (Bateman et al., 2002; Holmes and Adamowicz, 2003). Past studies addressed this limitation by reducing the number of attributes. However, this approach is not possible when a large number of attributes require valuation, as in this case.

As an alternative, a PPCE can address the problem of a large number of attributes (Chrzan and Elrod, 1995). PPCE presents a subset of the attributes that changes per choice set, allowing respondents to choose between profiles regardless of the total number of attributes (Chrzan, 2010). This prevents overly taxing the time and attention of respondents even with a very large number of attributes (Chrzan, 2010). Task bias can be avoided by ensuring that respondents properly understand the nature and levels of attributes not appearing in a choice (Bradlow et al., 2004; Chrzan, 2010).

Figures 16 and 17 use travel choice to show the main difference between DCE and PPCE choice task. The purpose of both the DCE and PPCE is to understand the impact of attributes and their levels on traveler preferences and/or choices. Each travel alternative is a profile than consists of the attributes (e.g., flight) and their levels (e.g., business or economy). The travel alternatives make up a set. In Figures 16 and 17, there are two travel alternatives and a basic plan. Respondents then choose the most preferable travel alternative in a choice set (i.e., choice task). In most settings, respondents complete a series of choice tasks rather than just a single choice task.

PPCE and DCE mainly differ on whether the attributes in each choice set change or stay the same. In this choice situation, there are nine attributes. In conventional DCE, considering human cognitive ability, only 5 (or 6) out of the 9 attributes are selected. Due to this, 4 (or 3) attributes have to be excluded from the travel choice. PPCE also uses 5 (or 6) attributes in a choice set. However, by changing the attributes included in each choice set, the impact of attributes can be understood without exclusion. For example, a researcher of this study may want to mainly understand the impact of optional tours on preferences. If hotel, flight and cost attributes cannot be excluded as highly important attributes for travelers, DCE can only treat two optional tours. In contrast, PPCE can treat all optional tours. That is, PPCE can fulfill the researcher's original goal.

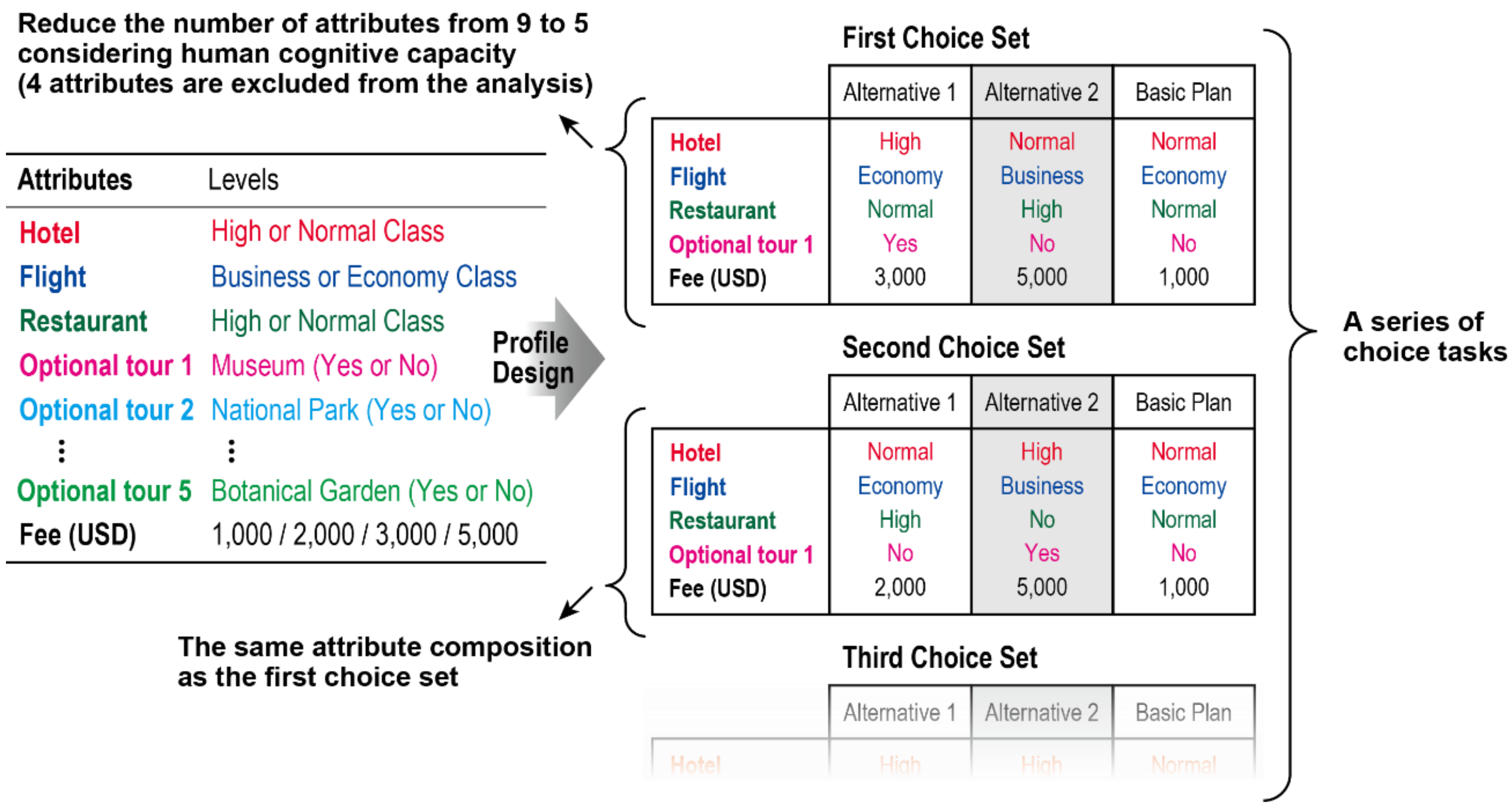

Figure 16. An example of discrete choice experiment for travel choice

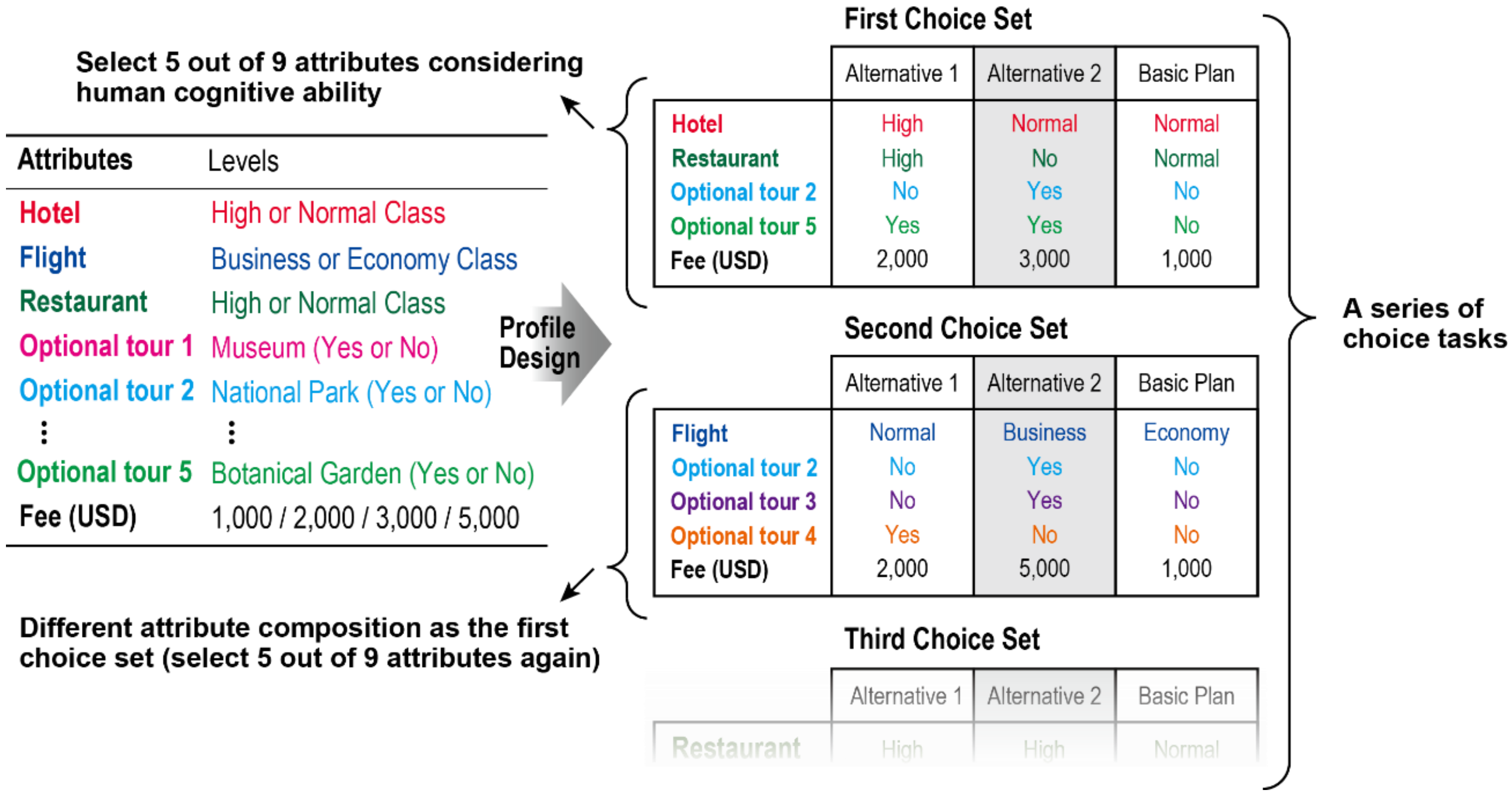

Figure 17. An example of partial profile choice experiment for travel choice

5.2.4 Estimation procedure

In this paper, a conditional logit model was applied. The conditional logit model is based on random utility theory, which assumes that the respondents' utility function can be expressed as the sum of a deterministic term expressed as a function of factors that influence utility, and a random term that cannot be observed by researchers. The utility for a profile i can be represented as

$$U_i = V_i + \varepsilon_i, \qquad (25)$$

where U_i is the total utility for profile i, V_i is an observable deterministic term, and ε_i is an unobservable random term. The probability that profile i will be chosen from choice set C is equivalent to the probability that U_i is larger than U_j, the total utility for any other profile j, as described by

$$\Pr(i) = \Pr[U_i > U_j] = \Pr[V_i - V_j > \varepsilon_j - \varepsilon_i] \; \forall j \neq i, \forall j \in C. \qquad (26)$$

A conditional logit model (McFadden, 1973) assumes that the error term is distributed as type-I extreme values. The probability that profile i is chosen is derived as

$$P(i) = \exp(\mu\beta x_i) / \textstyle\sum_{j \in C} \exp(\mu\beta x_j). \qquad (27)$$

where the deterministic component is expressed as linear in parameters: $V_i = \beta x_i$, where x_i is a vector of observed variables and β is a vector of parameters. The attribute parameters are estimated by the maximum likelihood method, and the scale parameter μ is generally assumed equal to one (Ben-Akiva and Lerman, 1985).

PPCE modeling proceeds as for a typical DCE, except that missing attribute levels need to be identified. The analyst accomplishes this using effects coding (Chrzan, 2010). In addition, the theoretical model shows that PPCE estimates would not be biased, as long as the attribute of payment amounts are always included in choice sets, and all attributes that do not appear in subsets of attributes are assumed to remain at the status quo levels (Kuriyama, 2017).

5.3 Results

5.3.1 Descriptive statistics

From the dataset, respondents who finished a series of PPCE choice tasks within an impossibly short time were removed. This left 719 respondents out of 1,109 for the PPCE analysis. The 719 respondents included 89 respondents who always chose the status quo profile. There was no statistically significant difference in terms of sex and age between these 89 respondents and the remaining respondents. Unfortunately, a question asking why these respondents always chose the status quo profile could not be included because of space limitations of the survey.

5.3.2 Conditional logit results

Data obtained from the survey was analyzed using the conditional logit model, which is the basic model used in DCE studies. The conditional logit model is often used in assessing average preferences because it assumes constant parameters among all respondents (Train, 2009). Table 14 presents the estimated results of the conditional logit model. A statistically significant parameter with a positive (negative) sign means the corresponding attribute would positively (negatively) impact utility for respondents. For example, the estimated coefficient for 25% decrease in park areas, which provides the service of a "Forming the landscape," was −0.5184, and therefore decreases the utility. Conversely, the estimated coefficients for increases of 25% and 50% were 0.3163 and 0.1367, respectively, and these thus increase the utility.

In this study, the results was represented by using effects coding (Holmes and Adamowicz, 2003; Bech and Gyrd-Hansen, 2005). The effect-coded variable for each qualitative or quantitative level is then set equal to 1 when the level is present, –1 if the arbitrary reference level (status quo) is present, and 0 otherwise (Bech and Gyrd-Hansen, 2005). The status quo level (0% change) was obtained through the negative of the sum of the other levels: –(–0.5184 + 0.3163 + 0.1367) = 0.0654. The estimated parameter for tax payment was negative and statistically significant, as was an alternative-specific constant for the status quo profile.

For the assessment of the process of renovation and the revision of future vision, WTP was investigated to confirm the economic efficiencies using cost-benefit analysis in light of ongoing budget cuts. Using the estimated utility parameters, the WTP was calculated. For example, the effect of 25% increase in park areas that provides a service of "Forming the landscape" was 0.3163 (Table 14). The effect of the tax payment of 1 JPY on respondent utility (marginal utility of income) was also calculated ($-0.3729 \cdot 10^{-3}$). The WTP for 25% increase of UGS that provides the service of "Forming the landscape" was obtained by dividing the estimated parameter of "Forming the landscape" by the marginal utility of income, after considering their signs (i.e., $-0.3163/-0.3729 \cdot 10^{-3}$). The formula for the calculation of WTP is

$$WTP_l = -\frac{dV}{dx_l} / \frac{dV}{dx_{tax}} = -\beta_l / \beta_{tax}, \qquad (28)$$

where x_l is the lth SEF variable, x_{tax} is the tax payment, and β_l and β_{tax} are the estimated parameters. Table 14 details the WTP using the estimated parameters.

Table 14. Conditional logit results

Services from ecosystem and facilities		Conditional logit model: coefficient		WTP†
1. Forming the landscape				
25%	decrease††	–0.5184	***	–1,366
±0%	change	0.0654		172
25%	increase	0.3163	***	833
50%	increase	0.1367	**	360
2. Conserving biodiversity				
25%		–0.3843	***	–1,013
±0%		0.0115		30
25%		0.1267	**	334
50%		0.2461	***	648
3. Providing places to interact with the forest				
25%		–0.4836	***	–1,274
±0%		0.0484		128
25%		0.2317	***	611
50%		0.2036	***	536
4. Providing lawns				
25%		–0.2881	***	–759
±0%		0.0463		122

Services from ecosystem and facilities	Conditional logit model: coefficient		WTP†
9. Providing parking lots			
25%	–0.2065	***	–544
±0%	–0.0765		–202
25%	0.1442	**	380
50%	0.1388	**	366
10. Providing playgrounds			
25%	–0.2375	***	–626
±0%	0.0949		250
25%	0.1115	**	294
50%	0.0310		82
11. Providing places for learning			
25%	–0.1355	**	–357
±0%	0.0051		–13
25%	0.1823	***	480
50%	–0.0418		–110
12. Providing a place for events			
25%	–0.1018		–268
±0%	0.0709		187

25%	0.1834	***	483	25%	0.0830		219
50%	0.0584		154	50%	–0.0520		–137
5. Providing places of interest with flowers				13. Providing a place for community activities			
25%	–0.3554	***	–936	25%	–0.0615		–162
±0%	0.0370		97	±0%	–0.0082		–22
25%	0.1793	***	472	25%	–0.0440		–116
50%	0.1392	**	367	50%	0.1138	**	300
6. Providing facilities for children				14. Providing eating areas			
25%	–0.3045	***	–802	25%	–0.0787		–207
±0%	–0.1059		–279	±0%	0.1067		281
25%	0.2151	***	567	25%	0.0438		115
50%	0.1953	***	515	50%	–0.0717		–189
7. Providing facilities for the elderly				15. Providing evacuation sites			
25%	–0.2106	***	–555	25%	–0.4292	***	–1,131
±0%	0.1139		300	±0%	–0.0775		–204
25%	0.1065	**	281	25%	0.2000	***	527
50%	–0.0098		–26	50%	0.3067	***	808
8. Providing cultural facilities				Tax payment ($\cdot 10^{-3}$)			
25%	–0.0751		–198		–0.3729	***	
±0%	0.0395		104	Alternative-specific constant			
25%	0.0396		104		–0.4643	***	
50%	–0.0040		–11				

The number of observations	23006
The number of respondents	719
Log likelihood	–7178.79
Pseudo-R^2	0.0997

*** $p < 0.01$, ** $p < 0.05$,

† WTP: willingness-to-pay (100 JPY ≈ 0.90 USD or 0.80 EUR on April 3, 2019).

†† The four options for size of urban green spaces are based on the current amount of urban green spaces.

Figure 18 shows the result of the conditional logit model for ES and facilities. The WTP at 25% increase was highest for "Forming the landscape." "Providing evacuation sites" and "Conserving biodiversity" were both positively sloped, whereas all others, except "Providing a place for community activities," formed an inverted *U*-shape. These results indicate that "Conserving biodiversity," and "Providing evacuation sites" grow more desirable as percent of change in area increases. For the other SEF, this means the desirability decreases if there is too much change in area. Some attributes, such as "Providing cultural facilities," "Providing a place for events," and "Providing eating areas," had no significant effect on utility (Table 14).

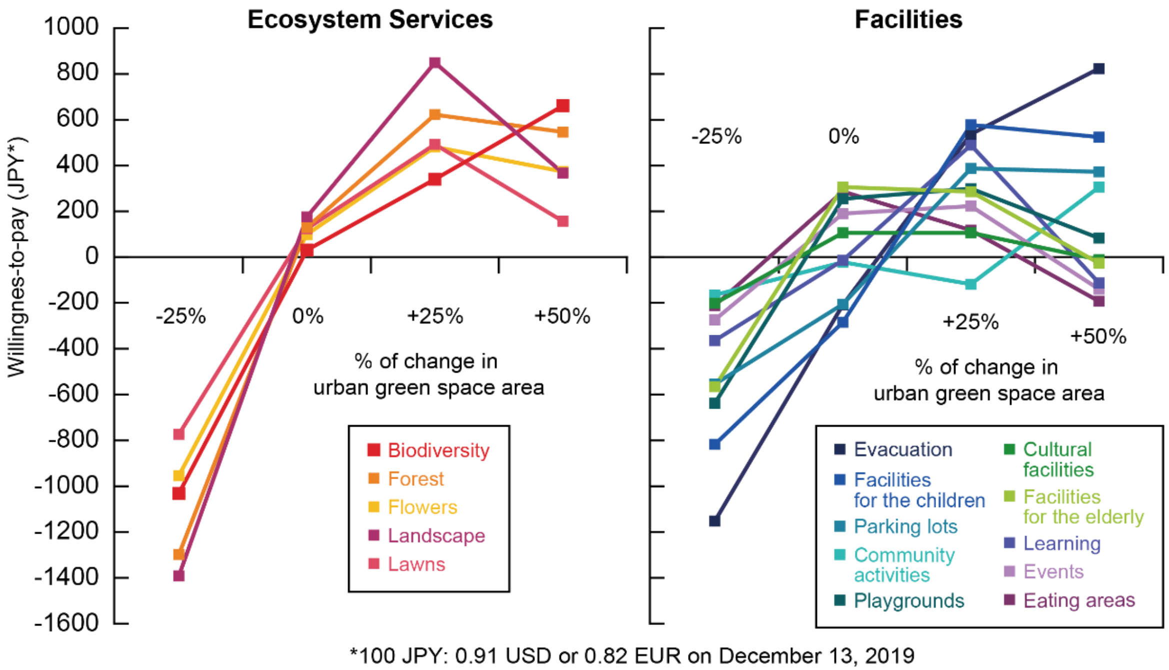

Figure 18. The result of the conditional logit model for ecosystem services and facilities

5.4 Discussion

5.4.1 The applicability of partial profile choice experiment

The first research question of this study was about the applicability of PPCE as an environmental valuation method. The present results are considered reliable for the following two reasons.

First, results appear to be consistent with economic theory. As shown in Figure 18, the 15 SEF are considered to be goods and services that increase users' utility. According to the logic of economic theory, as SEF increases, so does users' utility. In some cases, the increase in utility will diminish as SEF increases, as predicted by the law of diminishing marginal utility; in others, utility is expected to decline if disutility occurs due to an over-increase in SEF. All these considered, the line graphs for SEF can be expected to be positively sloped, inverted *U*-shaped, or flat, but not negatively sloped or *U*-shaped. Therefore, as can be seen in Figure 18, the results are consistent with the economic theory. These results indicate that the respondents considered the percent of change in UGS area for each SEF and adjusted their choice behaviors accordingly.

Second, the results are also consistent with previous studies. In this study, among the 15 attributes, "Conserving biodiversity," and "Providing places to interact with the forest" were highly valuated, with their WTP being the 2nd and 3rd highest at 50% increase, respectively. Previous studies also showed that these attributes were highly valuated (Alves et al., 2008; Varela et al., 2018). For example, Alves et al. (2008) examined preferences of older people for environmental attributes of local parks and found that a tree attribute was 3rd most highly valuated among 15 attributes. This consistency shows that PPCE can be as applicable as conventional DCE when considered as a method for environmental valuation. However, the goodness-of-fit was lower than in previous studies using conventional DCE. In conventional DCE studies, Pseudo-R^2 usually exceeded 2. In this study, Pseudo-R^2 when using the 1,109 samples was at 0.067. Even after removing 390 respondents who responded to the choice tasks too fast or always chose the status quo, the Pseudo-R^2 was still at 0.0997. There are two possible possibilities for this relatively low goodness-of-fit.

The first possibility is the respondents' lack of understanding of the PPCE choice tasks and therefore could not appropriately respond to them. As it was confirmed from the results of other questions in the survey that respondents at least understand the information in Table 14, it is safe to assume that the issue is in understanding the choice tasks rather than the scenario. As shown in Figure 15, one choice set includes 4 profiles (including the status quo) with 6 attributes. In the literature about environmental valuation, 6 attributes in a choice set is relatively large, even compared with previous studies of DCE. This may be the reason as to why the PPCE choice tasks might have been difficult for some respondents. However, as mentioned above, the results show that the greater the increase of SEF provided, the greater the WTP in general. Therefore, the choice tasks may not be totally incomprehensible. However, as mentioned above, the results show that the greater the increase of SEF provided, the greater the WTP in general. Therefore, the choice tasks may not be totally incomprehensible. Another possibility is the heterogeneity of preferences of SEF. Heterogeneity of preferences for ES and/or natural resource was also indicated in previous studies (e.g., Train, 1998; Boxall and Adamowicz, 2002; Mieno et al., 2016). This is most likely as evidenced by the Pseudo-R^2 of this study's preliminary result using a latent class model (Train, 2009; L135), which was over 0.2. However, detailed results are not shown due to space constraints. The degree of preference heterogeneity which occurs in PPCE studies is considered to be more intense, due to the significantly larger number of attributes compared to conventional DCE. Thus, intense heterogeneity may cause the low fit of the conditional logit model used in this study.

In conclusion, respondents appropriately changed their choice behaviors according to the attributes and levels when considering their trade-offs, as with conventional DCE. However, the goodness-of-fit was lower than conventional DCE studies, thus there is a need for care when interpreting the results, despite it being meaningful to adopt in raising the PPCE issue.

5.4.2 Providing facilities for children and the elderly and evacuation sites

The second research question of this study is to understand the demand for providing facilities for children and the elderly, and evacuation sites as a way of revising the future vision of UGS in the Sapporo city areas. The first discussion is about the facilities for the children and the elderly.

As shown in Figure 18, respondents valuated both facilities for the children and the elderly. However, the WTP for providing facilities for children is considerably larger than that for the elderly. Specifically, at 25% increase, the WTP for providing facilities for children was 567 JPY, while those for the elderly was only 281 JPY. The WTP for “Providing facilities for the elderly” at 0% change (maintain the status quo) was notably the highest among all SEF. This means general public disagreed with decreasing the area of providing facilities for children, while they were contented with the current situation of providing facilities for the elderly. This is contrary to the initial assumption that the low birthrate and aging population would lead to a higher valuation of the facilities for the elderly.

One factor that may have affected this is that the survey sample did not include respondents aged 70 or older. However, even with the exclusion of respondents in their 70s and older, it would be safe to assume that those in their 50s and 60s, who will become elderly within 10 or 20 years, would appreciate a management plan that increases facilities for the elderly more. Nonetheless, even in an aging society, the results clearly indicated that facilities for children are given more importance than those for the elderly. This finding demonstrates that the seemingly valid statement that facilities for the elderly are in higher demand because of Japan’s low birthrate and aging population does not actually hold.

Secondly, the WTP of “Providing evacuation sites” tended to rise to the right. The WTP at 50% increase was 808 JPY, which was the largest of 15 SEF. This shows that respondents have considerable expectations for providing evacuation sites, thus, when carrying out park renovation, policymakers have to consider the selection of a valid UGS that can realistically provide an evacuation site to reflect such demand. The fact that the WTP for “Providing evacuation sites” was the highest at 50% increase may be surprising to some. However, in Japan, the role of UGS as evacuation sites has been given much attention (Masuda, 2003; Nishino et al., 2011; Ohara et al., 2012), and they have contributed as such (Yun, 2007). In this sense, the finding is understandable and symbolically represents the changes in the general public’s expectations of UGS.

5.4.3 Increase forest areas for recreation

Finally, preference about the attribute of “Providing places to interact with the forest.” was considered. In the Sapporo city area, there have been many efforts to increase forest area for recreation. However, as discussed, the required SEF are getting more diverse, and their demands are also increasing. Thus, continuing efforts to increase forest area may not be in line with the general public’s needs.

The results shown in Figure 18 show that WTP for 25% and 50% increases for “Providing places to interact with the forest” were highly valued (611 and 536 JPY, respectively). On the other hand, the WTP at 0% change for “Providing places to interact with the forest” was not valued. This result showed that the amount of WTP will increase if policymakers increase UGS of “Providing places to interact with the forest.” As mentioned before, previous studies also indicated that a forest attribute is highly valuated among UGS attributes (e.g., Alves et al., 2008). In this study, the WTP for “Providing places to interact with the forest” was estimated, so it is also possible to calculate which UGS are efficient to increase forest areas for recreation by using data of visitor numbers for the 29 UGS and land price data for their location. That is, it is possible to estimate the benefit of an additional forest area for recreation from the data of visitor numbers and the WTP and the cost of increasing the forest area from the land price data (or some other sort of opportunity cost), then compare the benefit and cost.

However, there is still room for discussion about the types of recreational forests that can be provided. An existing meta-analysis also showed that WTP estimates for forest management programs are sensitive to the program's objectives, particularly when linked to the provision of recreational services (Barrio and Loureiro, 2010). In practice, multiple ES can often be provided simultaneously in forests. Therefore, instead of increasing forest areas only for "Providing places to interact with the forest," policymakers could also meet the needs of the general public by increasing forest areas for recreation with other ES. For example, it may be possible to increase the level of satisfaction of the general public by establishing areas with water and wetlands to provide habitats for amphibian species rather than just forests for recreational uses, in light of the findings of Fuyuki et al. (2014). Unfortunately, this survey was designed on the assumption that all attributes are independent. Thus, it cannot directly valuate this kind of interaction effect (e.g., forest for recreation combined with conservation of biodiversity).

6 General discussion

6.1 Novelty of the dissertation

In this dissertation, two case studies were conducted to derive practical and objective data for an efficient renovation plan. First, ITCM made it possible to valuate 29 UGS. Unlike many previous studies that have limited specific sites, this study has included 29 UGS in the analysis to identify the attributes that affect the number of visits to each site. As a result, individual attributes such as having small children and motivations to visit such as walking or running were identified as attributes affecting the number of visits of UGS. In addition, it is also a novelty that the spatial layout of 29 UGS is considered based on the obtained results. As a result, it was found that there were a few large UGS with high CS in the northwest area, and that the site selection of visitors who use a specific function (e.g.., Observing animals and/or plants) is divided according to the characteristics of the site. The second novelty is that the problem of excess zeros which occurs using off-site survey should be considered and addressed by applying ZINB model. Although it is not a perfect approach to solve the issue of excess zeros, the results showed that the approach could contribute the solving the issue of excess zeros to some extent.

Through the KT model, the site characteristics, which were not dealt with in ITCM, were considered in the analysis, and it was possible to find out which of the environmental attributes of UGS influence the number of visits of 29 UGS. This is because the KT model made it possible to simultaneously consider frequency selection and site selection for 29 UGS. As a result of the analysis, it was found that sports facilities and barbecue areas were environmental attributes that affect the number of visits of 29 UGS. In addition, cost and benefit analysis also was possible. As a result, the purchase of commercial or residential land for conversion to and expansion of UGS was revealed to not be economically efficient. It was also found that the benefits of expanding one hectare of UGS exceeded the cost of suburban land purchases (the benefit from the purchase of suburban forested land to expand the area of UGS by 1 hectare exceeds the costs of purchasing the land). In conclusion, this study is meaningful in that the KT model is effective for understanding UGS visit behavior and can be proposed as an approach for determining the economic efficiency of UGS expansion at the urban level. In addition, this study is meaningful in that it is the first case study about UGS using KT model.

Finally, by using PPCE, it was possible to valuate the preferences of non-use values that were not addressed in the ITCM and KT model. As a result, the public’s preference for conserving biodiversity was found to be high. In addition, 15 SEF composed of various ES and facilities provided by UGS were simultaneously analyzed to identify the general public's preference. Due to the limitation of the number of attributes that can be analyzed in the conventional DCE method, it would have been difficult to valuate the 15 attributes that were addressed in this study. However, through the PPCE, 15 attributes could be considered at the same time, so that it was possible to identify which of the 15 attributes were preferred by the general public. The result showed that preference for ES was generally higher than facilities, and there was preference for new SEF that were not previously considered such as conserving biodiversity and providing evacuation sites. This is a novelty of the PPCE study that cannot be obtained without considering 15 attributes at the same time.

In conclusion, the above results will be meaningful for policymakers in developing more realistic and effective renovation plans based on the general public’s opinion. Specific suggestions based on the results are described in the following sections.

6.2 Suggestions for renovation plan of urban green spaces in the Sapporo city area

The following are suggestions for policymakers to consider when establishing a renovation plan for UGS in the Sapporo city area. First, the ITCM results show that due to budget constraints, Sapporo city's renovation plan with a focus on specific functions of certain UGS is justified. According to the ITCM results, visitors are visiting UGS for various reasons, and the UGS visited differ according to the purpose of the visit. For example, visitors who want to observe wild animals and/or plants have been restricted to specific UGS located in central areas and in some suburbs. Nakajima and Maruyama park, which are the central areas, are rich in greenery. Also, the suburban Takino suzuran hillside park and Yurigahara park have famous gardens and Nopporo forest park has large forests and wildlife bird watching sites. That is, visitors are focused on visiting UGS that function as sites for observing animals and/or plants. Observing animals and/or plants is one of the attractive ES which is provided by UGS, but that doesn't necessarily mean that this function need to be extended to all UGS. Therefore, policymakers need to develop a renovation plan that takes into account two types, which are divided into central and suburbs.

The second suggestion relates to the consideration of spatial equity. It was also confirmed by the ITCM results that some regions did not consider spatial equity. For example, the northeast region showed fewer large UGS with high CS compared to other regions. In addition, for residents in areas located in the outskirts of the city, it is inconvenient to access large UGS around the central area or UGS that have high CS. Based on this result, it is expected that the benefit of people living in the northeast is relatively lower than that of people living in other regions. This is because large UGS with high WTP are far away, which means they incur travel costs, resulting in smaller CS. Currently, most of the city of Sapporo is in development, thus making large UGS in the northeast area is quite difficult in terms of land security. Therefore, policymakers will need to make efforts to improve satisfaction by providing priorities in the implementation of renovation or by securing the budget for the maintenance of the relevant UGS.

Third, policymakers need to consider new SEF. The PPCE result indicated that providing evacuation sites and conserving biodiversity were the most important in their respective categories, and thus, of the 15 SEF. The UGS's role as evacuation sites, which has already been mentioned in previous studies, has been confirmed in some studies to be a role that UGS can sufficiently serve. However, it is not known how the public thinks about this. Therefore, in this study, the general public's preference for providing evacuation sites was identified, with the public regarding it as important. Meanwhile, there is also high preference for conserving biodiversity. Currently, conserving of the biodiversity is an important concept when dealing with ES in UGS, but it was not known how important it was to the public. As a result of the PPCE, it has been found that the concept of biodiversity is also important to the public, therefore policymakers need to establish a renovation plan to implement biodiversity. On the other hand, existing services and facilities for recreational needs were also important. For example, according to PPCE result, attribute of "providing a place to interact with the forest" was second highest among ES attributes. This means that general public still considered important by the public. Also, KT model result showed that the benefit of expanding some UGS by 1 hectare by purchasing suburban forested land exceeded the cost of the purchase. However, there are also some UGS where expansion cannot be considered economically efficient. Therefore, policymakers have to consider these results carefully when they consider renovation plans. Individually, PPCE and KT may show promising results, but it would be more realistic to interpret and consider both at the same time.

The fourth suggestion considers the low birthrate and the aging population. In the early stage of this dissertation, because the social phenomena of a low birthrate and an aging population, it was anticipated that the needs of the public would place more emphasis on providing facilities for the elderly than for children. However, based on the result of Chapter 4 and Chapter 5, this assumption was incorrect. As a result of the ITCM and KT model, respondents with small children had a high number of visits to UGS. In addition, according to result of ITCM, there were some places where the CS of the surrounding UGS was high in the area where the elderly lived, but this did not represent the overall trend. There are two possible reasons. First, the sample collection did not include respondents aged 70 and older. The second is the possibility of elderly people using smaller UGS near their home. Although careful interpretation is needed regarding these two reasons, it is still surprising that the overall preference of respondents is focused on children's facilities rather than facilities for the elderly. The results of the PPCE also indicate that facilities for children are preferred over facilities for the elderly. Therefore, the above results can be interpreted that the low birthrate and aging population do not necessarily equate to increasing the facilities for the elderly or decreasing the facilities for the children. Policymakers need to consider these findings and plan UGS' services and facilities accordingly.

6.3 Limitations

The limitations of this dissertation are summarized. Chapter 4 targeted large UGS in the Sapporo city area and aimed to understand benefit of recreation and visitor characteristics using ITCM and KT model. Chapter 5 aimed to understand benefit from ES and facilities using PPCE. However, there are still some limitations that need to be undertaken.

One common limitation of both chapter 4 and chapter 5 is sampling. The sample used in this study excluded respondents who were 70 years of age or older. This is because it was expected that a sufficient number of female respondents in their 70s cannot be secured in advance. However, the population of people in their 70s in the Sapporo city area is roughly 225,000, and the population of people in their 80s is roughly 161,000, so the existence of these demographics cannot be ignored. Therefore, when considering the problem of low birthrate and aging population, it will be necessary to discuss the visit behavior of those who are 70 years or older to large UGS. Besides this, Chapter 4 also has another limitation. Only the recreation benefits of large UGS were dealt with in the analysis of the economic efficiency of expanding UGS in this case studies. According to the results of Chapter 5, UGS are expected to provide for conservation of biodiversity and serve as evacuation sites, indicating that if, for example, recreational benefits and conserving biodiverity can occur at the same time in an expanded UGS, the benefit results may improve. In view of these benefits in the future, verification of economic efficiency is required.

The limitations of the Chapter 5 are as follows. First, a simple scenario with brief explanations of SEF (respondents were given only the information shown in Table 14) was used. Interaction effects between the attributes mentioned above were also not considered. Despite this, the findings can help policymakers understand preferences regarding each SEF at the city level. They can also be used to inform an overall direction for the management policy of individual UGS. The findings may not, however, be applicable for the practical management of each UGS. A PPCE survey scenario that can provide more realistic results for practical management without compromising respondents' understanding should be considered in future studies. Second is that the study's analysis did not account for a heterogeneity of preferences. Previous studies have indicated that preferences for ES and/or natural resources are heterogeneous (e.g., Train, 1998; Boxall and Adamowicz, 2002; Mieno et al., 2016). The relatively low goodness-of-fit of this study (pseudo-R^2 = 0.0997) is assumed to be due to this limitation, given that the pseudo-R^2 of preliminary results using a latent class model (Train, 2009; L135) for considering preference heterogeneity was over 0.2. The third limitation is that the study did not exhaustively address all aspects of the applicability, feasibility, or reliability of PPCE. Many existing studies have focused on the complexities of choice tasks (Bradley and Daly, 1994; Mazzotta and Opaluch, 1995; Swait and Adamowicz, 2001a, 2001b; Hensher, 2006; Dellaert et al., 2012; Hess et al., 2012; Meyerhoff et al., 2015). As shown in Figure 15, one choice set included four profiles (including the status quo) with six attributes. In the environmental valuation literature, this is a relatively large number of attributes for a choice set, even when compared with previous studies of DCE. Greater discussion of these issues based on prior research is needed.

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