ABSTRACT

ECOLOGICAL RESTORATION PARKS IN XI'AN, CHINA: AN EVOLVING TYPE

by
Han Yan

This dissertation examines four urban ecological restoration projects used as public spaces in the city of Xi'an, China. The overall goal is to understand the social and ecological implications of the site features at both design and planning scale and define what is ecological restoration in China's urban context. The result of the research shows that the top-down planning initiatives approach for establishing ecological restoration sites in urban areas that meet the need for more public open space in addition to restoring healthy urban ecological systems is very different from the definition of what is traditionally understood as "ecological restoration". The impact of the four sites is evaluated through ecological aspects of vegetation productivity and vegetation structure diversity, and through the social aspect of public user and uses. The mapping of changes over neighborhood development shows that the ecological restoration parks are becoming center elements in facilitating the development around their immediate surroundings, which is the result of both state level planning strategies, and the parks influence over the local housing market. The study shows that design techniques that address the promotion/limitation of public access is an important element that defines ecological restoration parks as a unique type that seeks balance between the performance of urban ecological system and public involvement.

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CHAPTER 1

INTRODUCTION

Public spaces are all around us in cities providing opportunities for people to move around and to spend time outside of their private realms. Well-functioning public space prioritize the needs of its human users over the needs of animals and plants, which is the goal of ecological restoration projects. In this chapter, I describe another type of public space, ecological restoration parks, which attempt to balance the needs of human users with those of animals and plants. Traditionally, ecological restoration has been defined as returning a site to a "pre-disturbance" state by intervening with design and maintenance practices to create a self-sustaining community of terrestrial or aquatic vegetation and animals, such as birds, fish, turtles, which would otherwise be endangered in increasingly urbanized environment. In most cases, public use is not a goal of these sites, since the primary goal is to restore healthy ecological functions. But that approach is now changing.

In recent years, the growing population in many cities in China has caused massive expansion of urban areas, resulting in people's demand for an improved quality of life, including more public open space. At the same time, China is experiencing environmental problems, especially in urban areas, due to both global environmental crises and regional problems. The degraded ecological system in urban areas requires the restoration of eco-system functions through design interventions. Consequently, planners of many ecological restoration projects in China now establish ecological restoration sites in urban areas that meet the need for more public open space in addition to restoring healthy urban ecological systems. They do this by making the ecological restoration sites publicly accessible. The employment of particular design features, maintenance routines, and programming of public activities encourage public use of these sites. In fulfilling the dual purpose of restoring healthy ecological systems and encouraging access by the public, ecological restoration parks are an emerging type of public space.

By reviewing and conducting an in-depth study on four projects in Xi'an, this study demonstrates new criteria of evaluation ecological restoration as a type of public space. Detailed study of the cases is presented to evaluate their impact on social- ecological performance of these parks.

CHAPTER 2

BACKGROUND

2.1 Recent History and Current Status of Urban Development in China

Industrialization in China has occurred at a significant scale from the 1950s to today. The majority of industries supporting China's growing economy is in manufacturing which has led to significant increases in energy consumption. China built its economic growth on low-cost exports of machinery and equipment. It is reported that in 2017, $1.7 trillion of raw materials were imported for supporting those export business(Amadeo, 2018). In transforming the imported raw materials into manufactured exportable goods, local and regional environments suffer from the consequences of industrialization in all dimensions: polluted waterways, air and soil; deforestation; climate alteration, etc. (Zhao et al., 2006). Cities are expanded or even created to meet the demand of labor market in industrial dependent regions. The intense industrialization process in China is reshaping urban environment through direct alteration of environment and indirect influence on the trajectory of urban development.

Urbanization has also resulted in a series of social and ecological consequences at a national and local level. In 2004, The Chinese Statistical Bureau reported that during the early 1980s, 18% of China's population lived in cities, but this rose to 39% by 2003, while the number of cities increased from 190 to 660 (including about 170 cities with a population greater than one million) over the same time period(Chinese statistical year book, 2004). China is also pushing ahead with a plan to move 250 million rural residents into newly constructed towns and cities over the next decade (Johnson, 2013). Urbanization at this massive scale and rapid speed has resulted in internal migration at unprecedented scale, and it is leading the whole country into a new level of social reconstruction. The polarization of income between urban and rural areas, increasing living costs and soaring work stress are all contributing to physical and mental health risks to urban and rural residents. The Expanding footprint of urban built environment causes major reductions in natural vegetation coverage (Fang et al., 2003) and reduction of pervious surfaces in general, which has led to many ecological consequences that will be discussed later in the chapter.

This section looks into the current environmental and social challenges of Chinese urban environment through the investigation on the history of China's urban development and environmental policies.

2.1.1 Brief History of China's Urban Development and Environmental Policies

The following section reviews the history of China's urban development and environmental policies starting from 1949, and discuss the importance of those polices on the current status of urban ecological and social environment.

Regime shift and industrialization: from 1949

Soon after the establishment of the People's Republic of China in 1949, the country underwent an economic and social movement by the central government. The movement aimed to rapidly transform the country from an agriculture dependent economy into a highly industrialized one. The emergence of additional cities in China started during this period of time, as well. At the foundation of the People's Republic of China in 1949, there were 120 cities. By 1952, there were 159 cities; and five years later by 1957, there were a total of 176 cities(Williams, 2017). However, many of these cities were simply "on paper" generated by the government's policy of reclassifying rural towns as cities. What actually happened was that the Chinese authorities simply changed the designations of many rural towns into cities. Under the nationwide policy of "industrialization without urbanization", millions were sent to rural area as a labor force for construction, ironically creating new urban centers because of the expansion of industrial factories and their living need (Williams, 2017). "Make steel and iron" was a nationwide policy for supporting this grand transformation. The wood board painting showing in Figure 2.1 portrait factory workers standing shouting slogans of the "Make steel and iron" movement in front of steelmaking furnace while throwing coals into the furnace.

One significant impact of this policy was an increased level of energy consumption. With coal being the major energy source for both industrialization purposes and also domestic heating purpose in the 1950s, many of China's environmental problems can be traced along the line. In the 1950s, the government ordered that residents north of the yellow river receive free heating from the coal-powered plants. A research team compiled government data later from 1981 to 2000 showing that hierarchy of pollution level following the geographic characteristic of this policy. (Cendrowski, 2014).

Figure 2.1 Wood board painting showing “Make Steel and Iron” movement.
Source: Artist: Xuanwei Zhu(Zhu, 1956)

Environmental awareness and government actions: 1950s

The problem associated with rapid nationwide industrialization was quickly identified by government leaders and a “vegetation improvement and natural recovery plan” was implemented with the support from several research institutes. In 1956, the state established the “Forest Protection and Recovery” policy, and a “twelve year reforestation” plan started soon after, aimed at making deserted land in the country green again(Qiu, 2015). Along with the effort to restore vegetation across the nation, water and soil protection researches were conducted by the Northwest China Institute of Water and Soil Conservation around the same time (Ren & Peng, 2003).

Figure 2.2 Post stamps released in 1958 showing government advocacy on vegetation improvement and natural recovery plan".
Source: China Philatelic Information

Cultural Revolution and impact on urban development: 1966-1976

During the Cultural Revolution urban residents were sent back to rural areas because at the time the concept of "city" and "urban" was considered associated with "bourgeoisie" and "capitalism", which were politically unacceptable. Around twenty million urban residents were reclassified as rural residents and moved to rural areas, the number of people relocated at the time accounts for nearly 18 percent of China's total urban population at that time(Williams, 2017). Urban residents were sent back to the countryside to be "re-educated" by farmers instead of being educated in universities. For that reason, most research about natural recovery, was interrupted from 1966 to 1976, when almost all research in China was halted.

In 1972, Chinese representatives attended the First United Nations Conference on the Human Environment, held in Sweden. The next year, 1973, the Environmental Protection Leadership Group was established. The first national environmental protection conference was held in Beijing in the same year, the 300 participants included local government officials, representatives from factories and representatives from academic(Xinhuanet, 2009). However, at the time, the Environmental Protection Leadership group remained without real power. By the time of the 1976 Tangshan earthquake, one of the most severe natural disasters in the pre-reform period, there was no specialized disaster management agency in the country at the time, although a crisis management center in response to the earthquake was quickly formed, there was no significant planning or established protocols, for coordinating various agencies. Although 100,000 troops were mobilized for the rescue effort, there were no professional rescue teams or specialized rescue equipment to speak of. It has been estimated that of those rescued, some 80% were saved by local people themselves(Suttmeier, 2012). The Tangshan earthquake marked the end of the Cultural Revolution and the beginning of the establishment of China’s new economic system, as well as legal systems including environmental regulatory system.

Economic transformation and urbanization: 1980s and 1990s

While recovering from the decade of the Cultural Revolution, China began in 1979 to rebuild a new legal system that had been almost entirely disrupted in the previous years. Since the passage of the draft Environmental Protection Law in 1979 shortly after the end of culture revolution, China’s environmental law framework has grown to include more than 20 major statutes and countless State Council regulations, standards and other legal-norm-creating documents. The major laws include the Air Pollution Prevention and Control Law, the Water Pollution Prevention and Control Law and the Environmental Impact Assessment Law A. Wang (2007).

China experienced the fundamental transformation of China's economy from a socialist one to a more capitalist inclined system in 1980s, which blooms the economy starting from coastal urban areas and attracts increasing number of migrant workers from rural areas to work in urban centers. At the same time, as the new employments at coastal areas are majority in manufacturing industry, the nation made another transformation from agriculture to manufacturing. The expansion of manufacturing nationwide started to cause local and regional environment problems such as polluted waterways, air and soil; deforestation; climate alteration, etc. (Zhao et al., 2006) due to the lack of environmental awareness and environmental regulation.

Along with the nationwide economic transformation of the 1980s, the government underwent organizational changes at multiple levels. In 1983, the Chinese government announced that environmental protection would become a state policy. Then the 1990s brought an explosion of global interest in the environmental and sustainability dimensions of urbanization worldwide precipitated in part by two international landmark events. The first was the publication of the Report of the World Commission on Environment and Development (commonly known as the Brundtland Report) which introduced the concept of sustainable development into the common lexicon. The second was the United Nations Earth Summit in Rio de Janeiro in 1992(Rapoport, 2014).

Beginning of the conversation on Ecological Restoration: 2000s

In 1998, China experienced a year of serious flooding, which was considered the worst Northern China flood in 40 years. The floods resulted in 3,704 dead, 15 million homeless and $24 billion in economic loss(Perry, 2008). As a result, the Chinese government upgraded the Environmental Leading Group to a ministry-level agency, which then became the State Environmental Protection Administration.

The first restoration ecology symposium was held in 2000 to discuss the future of restoration ecology in China. At the time, the focus of ecological restoration in China was forest recovery. At the time three key forestry programs were in place: Three Norths Shelter Forest System Project, Grain for Green Project, and the Natural Forest Conservation Program. Between 1998 to 2006 China invested 179 billion RMB (ca.US$26 billion at an exchange rate of RMB6.82/US$ in December, 2008) (Cao, 2011). The second Symposium was held December 2002 to explore "Ecosystem succession theory and practice of ecological restoration" with 78 participants from mainland China and 15 participants from the United States and Canada(Ren & Peng, 2003).

On March 20, 2002， the City of Beijing experienced the most severe sandstorm on record, with visibility less than 500 meters, the official state-run Xinhua news agency reported. Sandstorms are frequent in the spring, triggered by sudden seasonal temperature changes, the Xinhua news agency reported. But in this incident of increasing frequent sandstorms, sand was picked up from the expanding deforested regions in northwestern China and Inner Mongolia. The progressive desertification in northern China exacerbated the sandstorm problem and made it an annual event in China.

The exacerbated frequent sandstorm triggered the national recognition of the environment degradation in China due to deforestation, this crisis upgraded the public and administration's awareness on the environment issues the country is going through. In May, 2003, the Chinese ministry of Environmental Protection issued "Guidelines on building ecological province, ecological city and ecological county", which was revised in 2007(Qiang, 2009).

Intensified public awareness of environmental issues: 2010s

The intensified industrialization and urbanization in the past decades caused consistent environment problems directly or indirectly and became increasingly noticeable and impactful. The publics' attention has been called to the environmental issue nationwide, and there has been increasing rise of awareness towards consequences of those issues to their everyday life. During the period of 2001 to 2007 more than 50,000 environmental protests were reported that dealt with issues of water pollution and air pollution. The government quickly picked up the severity of the ecological and social consequences of the issues and responded organizationally and through some nationwide policy and campaign.

In 2007, China launched the Green Transport and Health week campaign to help residents understand the importance of environmental protection and be mindful about saving energy. The campaign ended with a No Car Day Saturday(GreenCarCongress, 17 September 2007). In 2008, the State Environmental Protection Administration was officially replaced by the Ministry of Environmental Protection during the March National

People's Congress sessions in Beijing(A. Wang, 2007), aiming to form a more executional organization dealing with the environmental issues.

In 2011, the first issue of the Journal of Ecological Restoration was published in China, with the topic of “healthy and livable, sustainable development of cities” indicating that when the idea of ecological restoration was adopted in China it was at the scale of the city, and it intended to play fundamental role in shaping future city. Under that influence, many ecological targeted initiatives we saw are carried out at city scale, for example the eco-city movement, sponge city movement.

Although with the government’s continues effort on addressing the environmental crisis in the country, the problems still continues to intensify and caused more anxiety from the public. In 2012 alone, 2.53 million letters and 430,000 visits of citizens to government departments were attempted to seek environmental redress to the government in response to severe air pollution problems. Air pollution, as the most visible and public recognized issue received a five-year, US$277 billion plan from the government in 2013(Upton, 2013).

In April 2014, a new environmental law was passed (Valli, April 25, 2014). The new law empowered environmental enforcement agencies with significant punitive power, defined areas which require extra protection, and gave independent environmental groups greater operational and supervision power. The new articles of the law specifically address air pollution and call for additional government oversight.

In 2015, a self-financed Chinese documentary film by Chai Jing, concerning air pollution in China, went viral online. In the documentary “Under the Dome”, Chai Jing started making the documentary when her unborn daughter developed a tumor in the womb;

Chai blames air pollution for the tumor. The film combines footage of a lecture from Chai and interviews with public living through air pollution on daily basis and factory visits. The film criticizes state-owned energy companies, steel producers and coal factories, as well as showing the inability of the Ministry of Environmental Protection to act against the big polluters. It was viewed over 150 million times within three days of its release, but four days later was taken offline by authority after a total 300 million views. The documentary ignited heated debate in the country and brought public focus on air pollution to a whole new level.

Even though air pollution has become an inseparable part of the lives of millions of people in China especially in urban area, its causes have remained a mystery for many years. Difficulty in understanding the air pollution problem first started with the government's delayed recognition of the problem, and then intensified by the non-transparency of data. Lack of data and the restriction on data collection also limited the capability of understanding and resolving air pollution problem through research investigation. Members of disoriented public, who also lack any sense of participation, had never explored this problem in as much depth as the single, powerful documentary of 2015. Methods used for scrutinizing the issue as well as the data presented in this documentary were not as significant as the fact that it stirred up interests among the general public in participating in a conversation on such an unspeakable yet personal issue. The documentary is considered by some critics as a "Rachel Carson" moment in China, which has re-shaped the public's perception of their relationship to the environment.

Government's actions were followed again attempting to address the issues under the very much different public atmosphere. In 2016, the program of ecological restoration was discussed at the Chinese National Congress, the program recommends restoring the "natural ecological city" using a step by step plan to: repair damaged land and waterways, actively promote the restoration and reuse of wasteland, control the pollution of land and restore the natural environment. The "natural ecological city" refers to a new urban development pattern that aims to will include the restoration of natural ecological features in urban environments. Nineteen pilot cities were announced in 2017 to start implementation of this program(P. Lin, 2017). The launch of the ecological restoration initiative at a city-wide scale with such a large number of cities shows the government's determination to battle its environmental crisis and in some ways revolutionize the way we think about city and nature. From the notion of utilizing the natural environment as a tool for industrial and urban development, to the idea of bringing nature back to urban life and live as part of the natural environment, the concept of urban development in China is heading toward another direction.

2.1.2 Current Environmental and Social Challenges

The specificity of recent history and government policies shaped the urban form in China in its own unique way, the current and future urban development faces challenges that is specifically tied to that. This section reviews some of the major environmental and social challenges currently in China.

Environmental Challenges

In China, more than three decades of rapid industrialization have created enormous environmental challenges. The problems are, by now, well known. Seventeen of the 25 most polluted cities in the world are in China. Three-hundred million people, a population larger than that of the entire United States, do not have access to safe drinking water. An estimated 300,000 people die prematurely each year because of China's air pollution beyond legal standards. The initial cost estimation of environmental clean-up at a minimum of US$135 billion(A. Wang, 2007).

Air pollution. Air quality, as one of the most noticeable type of pollution in China has been drawing heated attention from the public and researchers in the country and abroad. In dealing with the recent intensified air pollution, Chinese government adopted the Air quality index (AQI) as a measurement for the quality of the air in specific location. The air quality index, an index for reporting daily air quality tells how clean or polluted the air is, and associated health effects. The US Environmental Protection Agency (EPA) calculates the Air quality index (AQI) for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide. For each of these pollutants, the EPA has established national air quality standards to protect public health (https://airnow.gov). To gain a perspective on China's air quality situation, Figure 2.3 depicts graphic from the Worldwide Air Quality - Real-time Air Quality Index Visual Map, showing visual map of air quality in China. The graphic shows that the air quality in China is overall unsatisfying throughout the country on Nov 22, 2018.

Figure 2.3 Real-time air quality index visual map of China
Source: aqicn.org

Other than understanding their air quality through the Real-time Air Quality Index, the Chinses public learns about the air quality through their own everyday observations of the presence "smog", a word developed by combining the word "Smoke" and "Fog." "Smog" describes a type of whether that with the visibility of "fog", but instead of consisting of cloud water droplets or ice crystals suspended in the air, it consists of fine particulate matters that is especially hazardous to health. In 2013, China started to publically report the real time measurement of PM2.5 (particles with an aerodynamic diameter less than 2.5 µm) in hundreds of locations.

Water pollution. Water pollution caused by rapid urbanization has exacerbated the lack of accessible drinking water because ground and surface water are contaminated. While levels of industrial wastewater discharge have largely stabilized, domestic wastewater has increased considerably. The total amount of released industrial wastewater fluctuated around 22 billion tons from 1995 to 2004; the domestic sewage discharge increased from 13.1 billion tons in 1995 to 22.1 billion tons in 2000, and up to 26.1 billion tons in 2004(*State Environmental Protection Administration*, 1995-2004). The increase was due primarily to the enactment of more stringent controls of industrial sources of wastewater, while domestic sewage was not controlled. In 2003, 91% of industrial wastewater was treated in contrast to only 32% of urban domestic sewage(*China yearbook of statistics*, 2004). A national survey conducted in 2004 of seven major rivers in China suggests that water quality measurements in 28% of 412 monitored locations were below the worst grade for the national standard for water quality in China. These results indicate that, for these location of the rivers measured at least, the water supply is highly contaminated and cannot be used(Shao, Tang, Zhang, & Li, 2006).

Soil pollution. The rapid development of industry and the increasing release of agrochemicals into the environment have led to growing public concern over the potential accumulation of contaminates such as heavy metals in the soil. Agricultural soils near urban and industrial area containing increasing levels of chemicals have become an increasingly serious problem. Vegetables take up heavy metals by absorbing them from contaminated soils or from atmospheric deposition in polluted air (Huang et al., 2007). A study conducted in 2007 focused on the distribution of heavy metal in top soils and subsoils in the Yangzhong district, Jiangsu Province. Compared to subsoils, topsoils had high Cd(cadmium), Hg(mercury), Pb(lead), Cu(copper), Zn(zinc), and As(arsenic). High levels of Cd and Hg were observed in most of the sampled agricultural soils. Concentrations of Cu, Pb, Zn, Cr (chromium) and Ni (Nickel) showed anomalously high concentrations round urban areas, with a decreasing amount away from the center of the city. High levels of As are recorded at both ends of the alluvion. Compared to data for 1990, Cd and Hg concentrations in top soils were much higher in 2005. The contents of As, Cu, Pb, and Zn showed a slight increase over this period, while Cr and Ni contents remained largely unchanged. Although these study result show relatively low levels of heavy metal concentrations in vegetables and wheat, these metals are potentially toxic, with detrimental effects only becoming apparent after decades of exposure(Huang et al., 2007). Heavy metal concentration in top soils expose farmers to health risks because of their daily contact with topsoil. Chang et al. (2014) investigated the extent of and associated health risks from heavy metal accumulation in leaf vegetables in agricultural areas of the Pearl River Delta in South China. Total concentrations of Hg, Cd, Pb, Cr and As were determined in 92 pairs of soil and leaf vegetables (flowering Chinese cabbage, lettuce, pakchoi, Chinese cabbage, loose-leaf lettuce, and Chinese leaf mustard). Samples were collected from seven agricultural areas (cities) (Chang et al., 2014). Research such as this indicates that the soil pollution in urban or adjacent urban area is beginning to post high risk on public health by entering food system.

Urban flooding. Urban flooding in recent years has become more and more severe in China. In a twenty-hour period on July 21, 2012, a storm hit Beijing. Within a day of the flooding (People's Daily Online, August 6, 2012). 56,933 people had been evacuated, while the floodwaters killed 79 people, causing at least 10 billion Yuan (US $1.6 billion) in damages and destroying at least 8,200 homes. In the city, more than 1.6 million people were affected by the flood overall (Netease News, July 25, 2012). A recent study suggests that the limited capacity of urban drainage systems is not the only cause of urban flooding in China. Loss of natural water bodies, new urban land uses and increasing of imperviousness of the ground surface, as well as fragmentation of natural water systems also play significant roles(Zheng et al., 2016).

Deforestation. As mentioned previously, deforestation remains an environmental major challenge in China for a long time. Before the 1950s, most of China's forests naturally regenerated themselves. Since then, the demand for timber has resulted in extensive cutting of forests: timber harvests increased from 20 million m^3/year in the 1950s to 63 million m^3/year in the 1990s(*China's Forestry Yearbook*, 1997). Government policy did not require that native tree species be planted after logging, but promoted planting of fast-growing tree species, such as larch (Larix sp.), poplar (Populus sp.), and Chinese fir (Cunninghamia lanceolata) (Zhang et al., 2000). Although a large-scale increase of plantation-style forests in non- forested areas increased total forest coverage in China from 5.2% in 1950 to 13.9% in 1995, natural forests declined to 30% of the total forest area in China and unit-area stocking of natural forests decreased by 32% (Zhang et al., 1999).The most common causes of deforestation, and the decrease of other original vegetation cover, was clearance for farming and settlement, including increasing safety from wild animals and fire, traditionally. The second most common cause was the use of wood as a source of energy for heating, cooking, and industrial processes, this is common traditionally and in the past decades especially in rural area. Another one was the supply of timbers for building more recently: for houses, boats, ships, and bridges, as well as for other forms of construction. In 1983, the People’s Republic of China placed a ban on using wood for floors, staircases, electricity poles, mine-props, railroad ties and bridges. China's reserves of wood per person today, at approximately ten cubic meters for each inhabitant, is only about one-eighth of the world average (Elvin, 2008).

Decreased biodiversity. The sharp decline in the quantity and quality of natural forests resulted in both the loss and the fragmentation of natural wildlife habitats. Studies have shown that at least 200 plant species have become extinct in China since the 1950s, and more than 61% of wildlife species have suffered severe habitat losses (Zhang et al., 2000).

Social Challenges

China's urban development also faces challenges that generated from its fundamental land use and residency system, some of the social challenges are especially to the country some are common issue faced worldwide under the influence of globalization. The following section reviews some of the challenges that essential to consider for understanding the obstacles in the field of urban design and planning.

Land use system reform and residency licenses. Under the impact of economic reform in the 1980s, with the purpose to introduce market mechanisms into resource allocations in order to improve economic efficiency, the former land allocation system underwent significant changes to remove any potential conflicts with the goal of economic reform. According to the 1991 regulations, there are two kinds of land transaction. One is the sale of land-use rights and the other is the transfer of land-use rights. The former defines "first" level land markets, where a municipal government, as a representative of the state, sells land-use rights to buyers for a fixed period through auction, tender, or negotiation.

The transfer of land-use rights defines the "second" level of land market. The adoption of the land-use rights system in China has had a positive impact on land development, government finance, real estate and housing development, infrastructure provision, and urban growth. For the first time in modern Chinese history, land now has value and can produce economic wealth. Land sales slowly increased from five lots in 1987 to 103,921 in 1996. The government has benefited substantially from these land policy reforms. Sales of land-use rights generated only 35.2 million RMB in 1987 and increased to 29,048 million RMB in 1996 (Ding, 2003).

Through this process, collectively owned land in rural areas was converted to state-owned land through land acquisition, to accommodate urban sprawl and its real estate development demands. The state did not pay market prices to acquire land from rural residents. Instead, it provided a compensation package that included job opportunities for farmers, housing compensation, compensation for the loss of crops, and the granting of urban residency licenses. Migration from rural to urban areas is restricted in China through the official household registration system. Under this system, each individual is officially registered as either a rural or an urban resident and rural residents were not permitted to freely move to or settle in urban areas. After 1991 rural residents were willing to give their land to the state in exchange for city residency licenses, making them eligible for social welfare such as medical insurance, pension and retirement plans, access to high-quality schools and subsidized agricultural goods that were not previously available to people with "rural residency licenses" at all. A city residency license is a locality residence license that allows the license holder to access social welfare that is geographically confined and to access local public goods (including schools) and crops at lower prices (Ding, 2003). Laborers, mostly previously farmers in rural area, acquire "temporary city residence licenses" in order to work temporarily in the city. The "temporary city residence license" does not cover the residency of their spouses or children. Neither does it entitle the license holder to educational opportunities in the city for their children. Length of a temporary city residence license varies and is decided by local administration.

Internal migration. Although migration from rural to urban areas is restricted in China through the official household registration system. Under the impact of economic reform, rapid economic growth in urban China has continuously widened the income disparity between urban and rural areas, which has provided a convincing incentive for rural residents to migrate to urban areas in search of employment opportunities and better lives. Studies have shown that a great gap exists between urban areas and rural areas in terms of per capita disposable income and per capita consumption. Calculated at current price the ratio of per capita disposable income of urban households was 2.57 times higher than rural households is in 1978, it falls down to 1.85 times in 1985, but increasing to 2.9 times in 2001, 71% higher than that in 1978 (Huijun et al., 2002).According to the China National Bureau of Statistics (2009), there were approximately 225.5 million rural-to-urban migrants in China in 2009, accounting for 31% of total rural labor and 17% of the total population in China. Rural-to-urban migrants from economic disadvantaged area work and live temporarily in urban areas without official urban household registration. Because of existing legal restrictions on employment and housing in urban areas, most of the migrants do not relocate permanently, they only that through the duration of their employment with a temporal residency license. The Chinese government has gradually been relaxing its control on rural to urban population-movement. Both central and local governments have started to relax some regulations on rural-to urban migration. For example, the Beijing government abolished the employment restriction in 2001 which controls the employment opportunities for migrant workers, and waived some mandatory fees for rural migrants in 2002 (D. H. Lin et al., 2011). When they move from rural to urban areas, migrants are facing changes in their working and living environments. Uneven distribution of education resource between urban and rural area result to the general poor education level for the migrant works, which lead to the ‘‘status-based’’ discrimination in cities.

Institutional segregation and residential segregation. Before 1949, land was privately owned and land transactions between seller and buyers were legitimate and frequent. After 1949, as the entire country started transitioning from private ownership to state ownership in the process of becoming a centrally governed, Communist country. Land reform was executed with the promise of reducing social inequality by confiscating land from the rich (landlords) and redistributing it to the poor. By 1958, all land was either state- or collectively owned. Urban land was state-owned whereas farmland was collectively owned with a few exceptions (Yang & Wu, 1996). This type of land ownership structure remains effective until the present day. As an export from the Soviet Union, “work units” were introduced as a basic building block of society to promote industrialization and consolidate proletarian interests. Work units as part of the company were not only providing employment opportunities, but also welfare institutions providing a wide range of services including everyday meals, child-care, medical care, and housing. In addition to office building designated to a specific enterprise, a “work unit” would also have housing units for their employees and families. Other facilities usually included are kitchens, dining halls, public bathrooms, clinics, kindergartens, grocery stores and theaters, which meant employees never had to leave the unit to survive, their acquaintance and social network would all be among people who shared the same profession and even people who works with them in the same office. The distribution of housing in the work unit was based on non-pecuniary criteria such as rank, title and age(Y. Wang & Murie, 1999). Compared to people outside the work unit, residents within it were very homogeneous in terms of profession and income in spite of differences in rank and title. Since these work units were also state owned, the location and amount of land allocated to a work unit depended on its political connections as well as the political environment in which socioeconomic functions and productions were planned and organized. The ill-defined property rights not only resulted in land-use deficiencies but also created social conflicts and land disputes(Zhang & Chai, 2014), under that context, walls and gates seems to be the best solution regarding these conflicts.

Currently many Chinese employees still work in more loosed kind of work units after many traditional work units have fallen bankrupt and changed into other types of institutional arrangements under the impact of economic reform in 1990s. The isolation of work unit communities from the outside often receives sharp criticism from Western planners for being a huge block which hinders regional transportation and causes traffic jams. The old “work units”, though undergoing some upgrades and improvements, still kept the original concept of enclosure with walls and Gates (Zhang & Chai, 2014). After major housing reform started in the late 1990s, many commodity housing units have been sold in the market. The majority of them are in the form of gated communities. Homeowners in these gated communities come from different backgrounds and have relatively various level in terms of incomes. They are very likely to be more heterogeneous than those in work unit compounds in the era of planned economy (Figure 2.4).

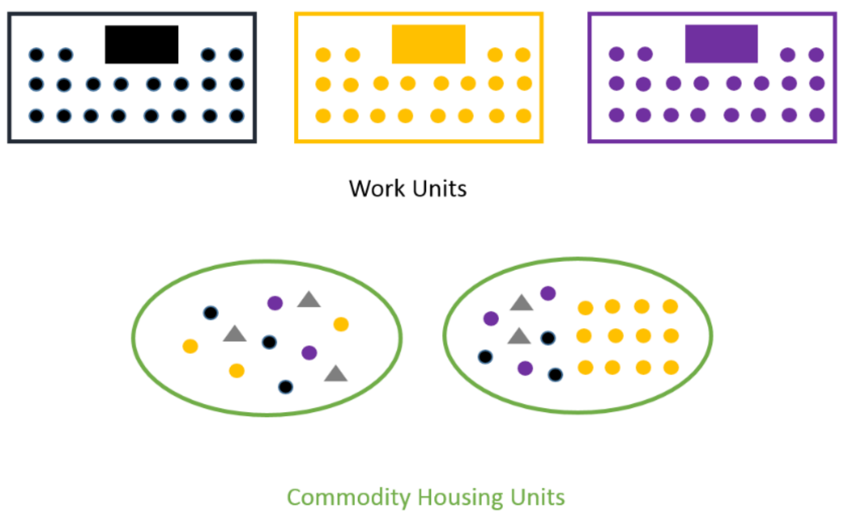


Figure 2.4 Work unites and commodity housing units.

Privilege and discrimination against "Others". During this period, "work unit" communities played an important role in distributing daily needs in a carefully calculated way, while guaranteeing the basic operation of everyday life through welfare facilities. Therefore, living in a "work unit" was considered a privilege. A privilege that represents a permanent job, stable income, higher standard housing, guaranteed education for children, etc. In addition, since the "work unit" employees are mostly trained for similar professional skills through similar educational institutes, living in a "work unit" becomes a symbol for being well educated. Among each other, neighbors and co-workers also share well established social norms that are considered acceptable for them. Even after commodity housing was introduced after the economic reform and change of land use system, gated communities are still considered the symbol of privilege. In addition to be better and upscale, these communities are usually developed in the best locations with well-equipped facilities for a good market effect. Meanwhile, since the goal for commodity housing development is to generate profits, it is not a surprise that most gated communities are developed for upper-middle class families to maximize profits, and outsiders often need a special pass to enter. Gated community became reserved for the wealthy class, who could afford to spare extra money to buy more space where livable space is limited.

In most of studies of gated communities in North America, the most common reason for residential segregation is people's prejudice and discrimination and perceived fear. "Whether it is kidnapping or bike snatching, Mexican laborers or 'ethnic changes', the message is the same: residents are using the walls, entry gates, and guards in an effort to keep the perceived dangers outside of their homes, neighborhoods, and social world (Low, 2001)". The possibility of integration between gated community residents and the "others" become close, incites fear and concern. Exclusive, private, residential developments is the response where they can keep other people out with physical barriers like guards and gates. The concept of "others" applies to the formation of gated communities in China as well. "Others" are defined and excluded via a combination of social, cultural, economic norm shared by a group of people. Upper-middle class families who share similar social economic status end up living in the same gated community and create their new relatively homogeneous social, economic norm, a norm usually exclude the lifestyle of people who live or even used to live below this social economic status. The rejection towards “others” promotes the market value of gated community development in urban area, and most of the gated communities are well-designed for the basic facility and their outdoor environment. Gated community along with some other measures of privatizing the public spaces acts as a physical justification for the uneven distribution of public facilities and natural resources, as people who cannot afford to purchase the house do not have access to the resources that is technically public owned.

CHAPTER 3

ECOLOGICAL RESTORATION

3.1 History and Definition of Ecological Restoration

Ecological restoration projects are well recognized globally as an approach to restore, reconfigure, or reimagine nature in settings that stand to benefit large numbers of people. With the evolvement of public and government's attitude towards urban ecology and environment issues globally, the need for recovering ecosystem services in populated urban centers has become increasingly essential. The idea of ecological restoration was institutionalized with the founding in 1988 of the Society for Ecological Restoration (SER).The Society for Ecological Restoration defines "ecological restoration" as an "intentional activity that initiates or accelerates the recovery of an ecosystem with respect to its health, integrity and sustainability". The practice of ecological restoration includes a wide scope of projects such as erosion control, reforestation, usage of genetically local native species, revegetation of disturbed areas, as well as habitat and range improvement for targeted species(Perrow & Davy, 2002).The restoration of functioning ecological systems within cities is being successfully attempted throughout the world. Human population benefits from the practice of ecological restoration through direct ecological services or indirect social and health benefits.

3.2 The Global Restoration Initiatives Worldwide

The ecological restoration practices worldwide also had been implemented at varies scale. The term 'eco-city' itself can be traced back to the 1980s, when it was first created in the context of the rising environmental movement, by Richard Register through his Urban

Ecology initiative and the publication of Eco-City Berkeley. This led to the first international eco-city conference held in Berkeley in 1990(Mega, 2000). Throughout the 1980s and early 1990s, it remained mostly concept. Later the concept was materialized through several sustainable initiatives at planning scale. For example, Curitiba (Brazil) was heralded as an early model eco-city, on account of its advanced, integrated public transport system first initiated in the early 1980(Macedo, 2004) . Waitakere (New Zealand) became known for its attempt to integrate sustainable resource management in its eco-city master plan(Laituri, 1996). Schwabach, in Germany, was selected by the federal government for a pilot study to develop a model for ecological city development to be emulated elsewhere in Germany (Mega, 2000). The current trend for eco-city began to demonstrate itself through the concurrent globalization and mainstreaming of the eco-city phenomenon. Thus there has been an increasing numbers of eco-city initiatives around the globe at city scale, some through the implementation of sustainable measurement as part of interconnected systems, others propose brand-new eco-city at master scale. Several policy at national and international levels have begun to promote eco-city innovation, such as the Clinton Climate Initiative (a collaborative project between the Clinton Foundation and the C40 Cities Climate Leadership Group), the European Commission's Eco-City Project, and the World Economic Forum's Slim City knowledge exchange initiative(Joss, 2010).

The eco-city is now a global phenomenon. Governments and developers in countries including the UK, Spain, India, South Korea, the USA and Jordan have also developed proposals for eco-city projects (Joss, 2011). In contrast with the smaller, bottom-up initiatives of the early eco-city movement, or the municipality-driven developments in

Europe in the late 1990s, contemporary projects command much higher-level support. Many of the new generation of eco-city and eco-town projects are initiated and/or supported by their national governments.

Eco-city from its originality by definition, was a global intertwined concept. Created in United States with earlier testing implementation across continent in Europe and South America, still uses a working definition that is in the process of updating and aiming to address socio-ecological issues shared across countries. The very fact that Eco-city and similar ecological orientated urban development initiatives has the universal functional objective to be problem solving, make the emergence of such city a perfect product of globalization. The newly emerged and re-planed cities are interconnected physically, conceptually and ecologically. In practice, the physical structure of the city is designed, in most cases, by big multinational design or planning consultant firm through competitions or higher level governmental celebrations. It is quite common for such newly developed cities to develop somewhat homogeneity characteristic, which may seem to be out of context sometimes.

In another aspect, more often than not, these eco-cities have been designed by big-name foreign architectural and engineering firms who plunged into the projects with little understanding of Chinese politics, culture, and economics — and with little feel for the needs of local residents whom the utopian communities were designed to serve.

Contemporary eco-city projects attempt to transcend these limits and are often driven as much by economic objectives as environmental ones. Although many eco-city projects market themselves as models for future urban development, it was argued by some(Rapoport, 2014) that they are better seen as sites of experimentation and innovation, helping drive broader socio-technical transitions. Even though the full realization of eco-cities in achieving their utopian ambitions may be limited by the realities of operating within a profit-driven, entrepreneurial planning environment. However, they can still play a valuable role, which is providing a platform for testing new ideas and technological innovations.

China will combine efforts in environmental protection and ecological restoration to ensure greener, more sustainable development, according to the country's newly approved guideline for environmental protection, part of the 13th Five-Year Plan (2016-20) (HU, 2016-11-17). Chinese government and public's growing awareness on restoring urban ecological system shows on one hand the urgency of environmental degradation issues faced by China, on the other hand indicate the evolving of environmental and ecological literacy at decision making level. As a pioneering step, the program of "Ecological Restoration and Urban Repair(ERUR)" was discussed presented at the National Congress of the Communist Party of China in 2015 as a means of restoring the "Natural ecological city" according to the Ministry of Housing and Urban-Rural Development of People's Republic of China ([MOHURD], 2016). The "ecological restoration" aspect of the ERUR program, is a step by step plan to: repair damaged land and water ways, actively promote the restoration and reuse of waste land, control pollution of land and restore the natural environment. "Natural ecological city" refers to a new urban development pattern that aims to include the restoration of natural ecological features in the urban environment. At the same time, the program addresses what does 'it' problems of decline of environmental quality in the old city, spatial disorder, and the destruction of historical and cultural heritage, and promotes the coordination and grace of buildings, street facades, skyline, color and environment. By April 2017, 19 cities in China had been selected as pilot cities for the ERUR program, projects under the program include cleaning waterways, constructing urban parks, restoring urban wetlands etc.

3.3 Ecological Restoration and Urban Repair Program in China

Industrialization has occurred on a significant scale in China from the 1950s to today. The majority of industries supporting China's growing economy are in manufacturing, which leads to serious environmental and ecological problems, both in cities and the surrounding areas. These problems include soil, air and water pollution, local climate alteration, and a major reduction in natural vegetation coverage(Elmqvist et al., 2015). Along with industrialization, urbanization also progresses at massive scale. China is pushing ahead with a plan to move 250 million rural residents into newly constructed towns and cities over the next dozen years(Johnson, 2013)

The Chinese government and the public are increasingly aware of the necessity of restoring urban ecological system shows on the one hand the urgency of environmental degradation issues. On the other hand, it indicates the evolving of environmental and ecological literacy at a decision-making level. This chapter reviews the history and definition of ecological restoration, global restoration initiatives and the development path of Ecological Restoration and Urban Repair Program in China.

CHAPTER 4

PREVIOUS RESEARCH

Since the sites selected to be studied in this research have both component of restoring ecological goals and being used as public parks. It is important to find the proper criteria to use in evaluating this new type of manufactured urban eco-system that invites recreational use. A review of literatures by Wortley and Hero in 2013 (Wortley, Hero, & Howes, 2013) summaries the breakdown of the attributes covered by literature that evaluates the successfulness of ecological restoration. A total of 301 articles coming from 71 journals were identified. It shows Ecological attributes were by far the most common measures used for post-implementation restoration assessments. 94% of articles only used measures of ecological attributes, and an additional 3.5% of papers also included social and economic attributes such as community engagement, participation in restoration or education. Most of the papers that included economic attributes focused on the cost or resource requirement of the restoration activity and the remainder looked at the impacts of restoration on the income and job creation. The three categories of ecological attributes include vegetation structure, diversity/abundance, and ecological processes. Diversity and abundance were the most frequently measured ecological attribute followed by ecological processes and then vegetation structure. Among the three categories, ecological processes are considered most difficult to measure.

Now as more ecological restoration efforts are taking place in urban settings, researchers are starting to acknowledge the importance of understanding the socioeconomic benefits/impacts of these practices, which is necessary to support natural resource management in close proximity to densely populated urban area. Traditionally, ecological restoration projects have not been parks because in most cases public use would conflict with the goal of restoration. Introducing human activities could lead to erosion of the surface visitors walk on, a change in the soil PH level, the introduction of invasive species and the introduction of birds or other animals that could negatively affect certain species of trees. Evaluating only the ecological performance of these parks does not justify the social significance of them. To find proper method for evaluating the success of ecological restoration projects in urban area is needed with the acknowledgment that the inter-related social-ecological performance of the project is more important than the survival rate of certain species exclusively. Therefore, the success of the design, management and maintenance strategies adopted in this type of park should be evaluated from both social and ecological perspectives. This chapter looks at how traditional ecological restoration projects and traditional public parks are previous evaluated respectively. and research and discuss the methods used in measuring the effectiveness of restoration projects, specifically focusing on ecological benefits, social benefits and economic benefits.

4.1 Ecological Studies

4.1.1 Ecological Functions

In rural or wilderness areas, the restoration of ecological systems is commonly practiced with the goal of reinvigorating certain plant and animal species so they will be self-sustaining and will be able to adapt to changes in the local environment. Vegetation coverage can vary over the course of the year, the type of plant species can change as long as coverage remains within an acceptable range. Consequently, the success of this kind of restoration project is often measured by calculating the survival rate of target animal and plant species such as birds and some native plant communities. Therefore, the design for this type of ecological restoration project focuses mostly on the health of animal and plant species. In urban environment, ecosystem services are generated in a diverse sets of elements, including: green spaces, such as parks, urban forests, cemeteries, vacant lots, gardens and yards, cam-pus areas, landfills; and blue spaces, including streams, lakes, ponds, artificial swales, and storm water retention ponds. (Elmqvist et al., 2015). Urban ecosystem services are generally attracted higher level of demand due to the number and scale of immediate local beneficiaries. Restoration of city parcels can add values to urban centers, but reestablishing ecological links to cities must first address many stresses that have been caused by human activities. In an urban context, the “restoration” of an eco-system is primarily focused on restoring ecological functions that benefit people, such as hydrological systems and the diversity of wildlife and vegetation. Once an ecological system is re-constructed, it functions as a supplement to engineering solutions in urban areas to address problems such as flooding and air pollution. Over the years, the ecological benefits of urban ecological systems have been thoroughly studied. This section focuses on ecological restoration specifically evaluated through on carbon sequestration, increasing biodiversity, urban flooding control, pollution reduction,

Regulates microclimates

The common practice of measuring climate regulatory value in urban eco-systems is either through direct shading effects or indirect carbon sequestration. Urban areas show climatic differences in comparison with more rural environments because of the heat island effect resulting from the effect of the buildings on air circulation, the materials used for the built environment, the use of fossil fuels and traffic. The ecological function of restored green eco-systems on regulating microclimate often is attained through carbon sequestration. Shade trees sequester carbon through photosynthesis, a process in which green plants take in carbon dioxide from the air and convert it into sugar. Carbon is then stored in plant tissue or soil. This process makes carbon inactive, in terms of its effects on the climate.

Akbari(2002) looked at climate regulation of urban trees from the perspective of wind shielding, evaporative cooling in Baton Rouge, Sacramento, and Salt Lake City. Data is collected on building characteristics and stocks for each building type and developed then simulated with the DOE-2 building-energy simulation program. DOE-2 is widely used for predicting the energy use and cost for all types of buildings, with a description of the building layout, constructions, usage, conditioning systems, and utility rates provided by the user, along with weather data, to perform an hourly simulation of the building and to estimate utility bills. The study considered several scenarios by placing trees around the building and the direct energy-savings potentials were calculated. Changes in the ambient temperatures were modeled in the program to estimate the indirect cooling effects of trees in reducing air-conditioning energy use(Akbari, 2002).

Similarly, but through a larger scale, Gill et al. (2007) from Manchester (United Kingdom) looked at the impact of green infrastructure on climate regulation employ energy exchange model. In quantifying the Environmental Functions, The energy exchange model uses surface temperature as the output, which is based on an energy balance equation. Data collection includes mapping of urban morphology types. Model runs were completed for the urban morphology types of categories with their current form, i.e. using proportional surface covers from the urban characterization, as well as for a series of development scenarios' exploring the impact on environmental functionality of adding and taking away green cover in key areas (Gill et al., 2007).

In general computer simulation is a helpful tool for conduct pre-implementation analysis on certain designs and strategies. However, relying solely on simulation is insufficient for verifying the level of association between vegetation and its cooling effect, since the simulation is programed with specific perimeters with sometimes untested assumptions. The simulations are unable to capture the full dynamic of the changing urban environment and could benefit from supplementing with onsite survey data. For example, in addition, for the energy exchange model, runs were completed where grass was excluded from the evapotranspiration proportion. This was intended to give some indication of the impact of a drought. Therefore, the model simulation is insufficient and unreliable for estimating the cooling effect.

To measure indirect cooling effect through carbon sequestration, Chaparro and Terradas (2009) studied the benefits of urban forests in the city of Barcelona. The study focused on the process of shade trees sequester carbon through photosynthesis, in which green plants take in carbon dioxide from the air and stored in plant tissue or soil. This process makes carbon inactive, in terms of its effects on the climate. Based on the field data and information obtained from the literature, the total carbon stored and the gross and net carbon sequestered by shrubs and trees in the city of Barcelona were calculated. Number of trees, carbon stored, net and gross carbon sequestered, leaf area and leaf biomass by specie were calculated by using UFORE methods or i-Tree user's manual. Researchers categorized the study area into residential, natural forest and institutional land use and then contrasted net carbon density sequestered per hectare for each category(Chaparro & Terradas, 2009).

Similar study was conducted in New York City(Nowak, 2007). To help determine the vegetation structure, functions, and values of the urban forest in New York City, data from 206 one-tenth acre sized field plots were sampled and analyzed using the UFORE model. The plots were divided among the following land uses: Commercial/Industrial (15 plots), Multi-Family Residential (10plots), Open Space (45plots), Public Facility (10 plots), 1-2 Family Residential (66 plots),Vacant Land (60 plots). Field data were collected by professional forest service consulting group. To calculate current carbon storage, biomass for each tree was calculated using equations from the literature and measured tree data. To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter to estimate tree diameter and carbon storage in the next one year.

In terms of microclimate regulation and energy consumption, the results obtained in both of the study with the UFORE model are not reliable, as the model is based on the

Californian coastal climate. In addition, Chaparro and Terradas (2009)'s field data on vegetation coverage is collected based on the 1:5,000 ortho-images released in 2004, which might be inaccurate as well for generating results for 2008. Sampling data from real sites that covers multiple land use types by Nowak (2007) is more reliable in that aspect.

Controls urban flooding

Urban green spaces play a positive role in rainwater-runoff reduction, by increasing the area of pervious surface. Pervious surface as one of the well-recognized green infrastructure design tools is proposed by replacing large area of concrete/asphalt surface into vegetated surface, which will slow down surface runoff by draining water into ground water system. Interception of rainfall by trees, other vegetation, and permeable soils in urban areas can also be crucial in reducing the pressure on the drainage system and lowering the risk of surface water flooding (Pataki et al., 2011). The dominant effect of impervious surfaces is to increase surface runoff and decrease infiltration of precipitation. In many natural ecosystems, 90% of water flow from uplands to streams is by subsurface flow Urban landscapes with 50–90% impervious ground cover can lose 40–83% of incoming rainfall to surface runoff whereas forested landscapes only lose 13% of rainfall input from similar precipitation events(Kaye, Groffman, Grimm, Baker, & Pouyat, 2006).

Humans change hydrology by altering water supply and drainage in their settlements and by constructing impervious surfaces that change the way in which water moves through urban ecosystems. Common approach of evaluating the pervious surface hydrological performance is to combined engineering models, with more traditional biogeochemical models that depict soil and vegetation processing of water(Kaye et al., 2006).

Gill et al. (2007) also looked at the influence of green infrastructure in urban area on controlling urban flood. The study first characterized the urban environment in the Greater Manchester area by stratifying and grouping land use units into 12 urban morphology types(UMTs) using digitized Arc GIS aerial photograph from 1997. The surface cover of each of the UMT categories was then estimated by aerial photograph interpretation of random points, final surface cover types included: building, other impervious, tree, shrub, mown grass, rough grass, cultivated, water, and bare soil/ gravel(Gill, Handley, Ennos, & Pauleit, 2007). It is understandable with the scale of this study, looking at regional images through Arc GIS is the few options that is phase-able, however, the decade old aerial photograph is questionable unless supported by site survey data for verification. Secondly, the surface cover categorization process could be improved by including the ground coverage types instead of only looking at vegetation types above. It is highly possible that some area seems to be covered with full vegetation from aerial photograph are actually tree pits within paved surfaces, more importantly, some ground surfaces might not be easy for identifying their permeability through aerial view. Therefore the study would be more reliable if the ground surface categorization were done by on site survey instead of random check points verification through aerial images.

Chen (2006) conducted study to assess the monetary value of urban green spaces in the built-up area of Guangzhou city. One of the variables used to evaluate the urban flood control is the retention ability of urban green spaces in Guangzhou. Several experts on urban green spaces planning and management were interviewed. Their suggestions were taken as references in the selection of sample sites. A total of 14 sample sites were chosen in City of Guangzhou spread through different land uses and administrative districts. The selection is based on the experts' suggestions while collecting information on green planning, related policies and practices at the municipal level. To keep the temporal term of the data consistent, Chen set the year of 2000 as the base year. Because of the consistency of data available. The state of urban green spaces in the study area is mainly based on the latest survey conducted by Guangzhou Landscape Bureau in 2000 and 2001, satellite images taken in December 1999, and color aerial photographs taken in October 2000 (at a height of 2000 m, a scale of 1:2000) (Chen, 2006).

Instead of perform model simulation like Gill et al. (2007), Chen (2006) calculates the retention ability of urban green spaces using equations adapted from literatures. Two scenarios of surface characteristics were assessed: scenario A means the current surface cover in the study area and scenario B is defined as that vegetation in urban green spaces that was hypothetically removed and transformed into typical urban surface (same surface characteristics as current cover types except for green spaces). For these two scenarios the volume of potential retention of rainfall event taken into account in 2000 could be calculated, the difference of which could therefore be estimated as the retention ability of existing vegetation in urban greens spaces in Guangzhou.

Reduces Air and Water Pollution

Urban vegetation is reported to improve air quality although this effect can be context dependent due to the high spatial and temporal variability in and among cities (Escobedo, Kroeger, & Wagner, 2011). By using cost-effective performance standard defined by the World Bank, Francisco J Escobedo et al., (2008) concluded managing urban forests for PM10 removal in Santiago was just as cost-effective as other PM10 reduction technologies and policies. In their following research, by monitoring hourly pollutant concentrations from two monitors: the Las Condesand and Providencia MACAM-2 monitoring stations, (Escobedo & Nowak, 2009) reported that PM10 air quality improvement by trees was 1.6 percent in areas with 26 percent tree cover to 6.1 percent in areas of 100 percent tree cover and varied according to socioeconomic strata, season, and pollutant concentration.. In this study, pollution removal differences among three different socioeconomic sub-regions (high, medium, and low socioeconomic status) are evaluated. These three socioeconomic sub regions are comprised of different population demographics, urban forest structures, and ambient pollution dynamics. These sub regions resulted from differing land uses, economic development, and cultural activity. Subsequently, pollution emission and concentration trends as well as urban forest structure differed among the sub regions. The Urban Forest Effects (UFORE) model was used to estimate the amount of air pollution removal by Santiago's three urban forest sub regions. Using 2002 field data and meteorological and pollution concentration data from July 2000 to June 2001, urban forest effects on pollutant dry deposition, were quantified using the UFORE model.

In 2008, Barcelona's trees and shrubs have depurated 305.6t of pollution from the air. From an economic point of view, this purification is valued at €1,115,908 a year (Chaparro & Terradas, 2009). The calculation includes primarily the elimination of O3, SO2, NO2, CO and PM10, during daytime because the pollution eliminated by the vegetation during the night is minimal due to the closed stomas. However, the study did point out the impact of VOCs released by vegetation on air quality. So the results was created of the species that improve air quality in Barcelona by weighting the individual species or genera according to the pollutants produced and the leaf biomass of the species or particular genus.

Phytostabilization is another practice of stabilizing toxic through plant's natural growing process. It involves the reduction of the mobility of heavy metals in soil. Immobilization of metals can be accomplished by decreasing wind-blown dust, minimizing soil erosion, and reducing contaminant solubility or bioavailability to the food chain. The addition of soil amendments, such as organic matter, phosphates, alkalizing agents, and bio solids can decrease solubility of metals in soil and minimize leaching to groundwater. The mobility of contaminants is reduced by the accumulation of contaminants by plant roots, absorption onto roots, or precipitation within the root zone. In some instances, hydraulic control to prevent leachate migration can be achieved because of the large quantity of water transpired by plants. This is usually applicable for sites that were previously disturbed or polluted. Phytostabilization has proved useful for the treatment of Pb, As, Cd, Cr, Cu, and Zn (Etim, 2012) and has been successful in addressing metals and other inorganic contaminants in soil and sediments(Best Management Practices for Lead at Outdoor Shooting Ranges, 2005)

Sustains Bio-diversity

By collecting both quantitative and qualitative data, Andersson(2007)'s study explore the relationship between different management practices in the three types of urban green areas and patterns of species richness and abundance. The study focused on three types of green areas in the urban landscape of: cemeteries, city parks, and allotment garden in Stockholm, Sweden. Andersson(2007) used species diversity and abundance of birds and bumble bees as indicators. Birds are point counted at 12 locations during winter and breeding seasons with the counting radius of 0-25 m, 25-50 m, and>50 m, and a count duration of 2 minutes and repeated for 5 times. Bumble bees are counted within 3 X 3 m quadrat where plant species were selected according to literature. Data from all sites were rarefied to 26 individuals, and the resulting estimate of species richness was used in the diversity analysis. Differences in species richness and abundance within each functional group, between sites, were analyzed using one-way ANOVA(Andersson, 2007).

Blair & Launer (1997) selected six sites near Palo Alto, California (all former oak woodlands) that represents a gradient of urban land use running from relatively undisturbed to highly developed and include a nature preserve, recreational area, golf course, residential neighborhood, office park and business district, to evaluate the species richness and Shannon diversity of butterflies from natural to the urban areas. Each site was divided into eight areas of approximately 2 ha that were walked for 15 min each between10:00 and 12:30 and, on a different day, between 13:00and 15:30 for each sampling period, making a total sampling time of 4 h for each period. Sampling was done only on cloudless days with minimal breezes. Researchers noted all species that were seen during each 15 min stretch and captured voucher specimens of the species that were difficult to identify(Blair & Launer, 1997).

Birds and butterflies are very commonly used as indicators for bio-diversity in eco-systems, especially when the study is associated with human interaction with eco-system. Birds and bufferfly, for one thing, they are easy to identify in outdoor environment, and also, known for attracting human attention. Comparing to Andersson(2007)'s way of counting technique, Blair & Launer (1997)'s method is less rigors for moving position of the observer add uncertainty to the accuracy of the counting, in addition, the collection of voucher can be difficult to control and is insufficient to verify the presents of species during a set period of time.

Reduces Noise

Green infrastructures like green wall, green façade and green roof in urban areas are studies for their acoustical values. A Study conducted in Hort Park, Singapore shows that the sound absorption coefficient increases with greater greenery coverage(Wong, 2010). By comparing eight different vertical greenery systems, the acoustics impacts on the insertion loss of building walls were evaluated. One of the objectives aim to determine the sound absorption coefficient of the vertical greenery system constructed in the reverberation chamber which is found to have one of the highest values compared with other building materials and furnishings. The result also shows as frequencies increases; the sound absorption coefficient increases. Another study(Van Renterghem, 2013) looks at the acoustical efficiency of green wall and green roof by measuring road traffic noise propagation towards the traffic-free sides of inner-city buildings (courtyards). The combination of green roofs or wall vegetation with roof edge screens seems most efficient. Green roofs, and wall vegetation in the street canyon were found to reduce noise rather independent of the position of the receiver in the courtyard. Roof screens and wall vegetation in the courtyard result in much higher spatial variation in acoustical efficiency.

4.1.2 Economic Value

Restoration sites usually are carefully monitored, as local conditions changes, additional plant species sometimes are installed. The progress of ecological succession requires one suite of species to mature and facilitate the next wave of introductions after restoration. Ecological restoration is an investment, not an expense. Ecological restoration was originally seen by many as a way of repairing small scale damage to landscapes caused by human land uses. Planners and government agencies now see nature in the city as having value in ecosystem services. These services that are not directly voted upon by city councils, but give real value, replace precious tax dollars in a city budget(Handel, Saito, & Takeuchi, 2013).

Saves Energy

For example, urban shade trees offer significant benefits in reducing building air-conditioning demand and improving urban air quality by reducing smog. The savings associated with these benefits vary by climate region and can be up to $200 per tree/year. In a study of Guangzhou's urban forests (7360 ha) in the humid subtropics, summer cooling effect of the urban forests was valued at RMB573.5×106/year, and contributed to an average saving of RMB12.5/year per home(Chen, 2006). The cost of planting trees and maintaining them can vary from $10 to $500 per tree. Tree-planting programs can be designed to have lower costs so that they offer potential savings to communities that plant trees(Akbari, 2002). The monetary benefits of vegetated urban green areas are well studies based on data from 25 urban areas in the USA, Canada, and China(Elmqvist et al., 2015). The challenges for a valid comparison between Chinese cities and the remaining cities described are due to differences in methodologies used. The estimation for Chinese cities are collection of literature review with various methods used to estimate the ecosystem services. The estimates for the remaining cities are based on a standardized data collection and analyses procedure using local data. In order to standardize and make the results comparable, values are calculated as Local Currency Unit/ha/year first using available information in the articles or by communication with the authors of the original or review publication. Then converted into 2013 prices and finally converted into USD using the purchasing power parity- conversion factors. All conversion factors used are based on the World Bank's World Development Indicators database of 2014. Information retrieved from literature in this study focused on local pollution removal, carbon sequestration and storage, regulating water flows, climate regulation/cooling effects and aesthetics, recreation and other amenities.

Cost of Reducing Air pollution

Several studies have attempted to measure the removal of air pollutants by urban forests in China. It is estimated that the monetary value of pollutant removal was RMB0.28×106/year for sulfur dioxide, and RMB0.91× 106/year for particulates in Lanzhou, China; In Beijing, study shows the removal value was RMB2.5 × 106/year for sulfur dioxide, and RMB17.1 × 106/year for particulates(Jim & Chen, 2009). An analysis (Nowak, 2007) of trees in New York City reveals that this city has about 5.2 million trees with canopies that cover 20.9 percent of the area. The urban forest currently stores about 1.35 million tons of carbon valued at $24.9 million. In addition, these trees remove about 42,300 tons of carbon per year ($779,000 per year) and about 2,202 tons of air pollution per year ($10.6 million per year).

Provide Urban Agriculture Opportunities

Urban agriculture is a growing trend now in many countries. It is reported(Altieri et al., 1999) that urban food gardens are helping to stabilize the supply of fresh produce to Cuba's urban centers. During 1996, Havana's urban farms provided the city's urban population with 8,500 tons of agricultural produce, 4million dozens of flowers, 7.5million eggs, and 3,650 tons of meat. This system of urban agriculture developed and managed along agri-ecological principles eliminate the use of synthetic chemical pesticides and fertilizers, emphasizing diversification, recycling, and the use of local resources.

Generate Direct Revenues

The cost effectiveness of operating urban open space operation has been key concern by planner. Whether the value of ecological services is sufficient to counterbalance the cost of operation and maintenance is also under discussion. Studies conducted at Liberty State Park, New Jersey has shown that the park has annual operating expenses of $3.5 million, and brings in $1.5 million in revenues. The remaining $2 million comes from the state budget for the park service, which is 0.00006 percent of the $33.8 billion New Jersey State Budget (Remaud, 2016). Meanwhile, the ecological service valuation and intrinsic values provided by the park using money generation models shows greater indirect value of this green public space in aspects of carbon sequestration, wildlife refuge, soil retention and hydrological services, storm water regulation and air pollution as well as tax generation (Rose-Wilen, 2017).

4.2 Social Studies

Public green space is considered to be directly connected to public health and environmental sustainability. Accessible green spaces contribute to solutions to deal with obesity and poor mental health, which associated with people’s inactivity. People seeking personal recovery also, through stewardship of green spaces, may achieve unanticipated social capital and natural capital outcomes. This section reviews studies that measures the culture and social values effects of urban eco-systems, specifically on overall human well-being, and affect public perception on urban ecological system.

Eco-gentrification

In cities, green spaces are studied to measures environmental justice in terms of their accessibility. Green space is not always equitably distributed. Access is often highly stratified based on income, ethno-racial characteristics, age, gender, (dis)ability, and other axes of difference(Byrne, Wolch, & Zhang, 2009). For example, analysis of park development in Harlem found that efforts to address environmental justice issues linked to park availability stalled because residents recognized that park development was primarily a strategy for real estate development and gentrification(Checker, 2011). It is an ongoing discussion in the social science discipline whether environmental remediation strategies in neighborhoods, which including but not limited to the creation of new green spaces might accelerates disappearance of working-class communities, as such improved neighborhoods become interested by developers to create more upscale community development.

Accessibility is a key element that distinguish traditional ecological restoration and ecological parks described in this dissertation. In traditional ecological restoration practices, access is usually very heavily controlled to reduce the influence of human activities. And when previous research investigate accessibility to green spaces, the common metrics is usually the measuring of area of green spaces per capita within certain radius. The problem of using only that metrics is that it does not capture the street level experience at landscape scale, which is very much important from the actual visitor's perspective. Also accessibility should also be measured through the availability among different social and economic groups.

Effects on Public health

The assessment of human well-being could be approached through many aspects. In Japan for example, correlation between longevity of urban senior citizens and the size of walkable green spaces is studied, independent of their age, sex, marital status, baseline functional status, and socioeconomic status(Takano, Nakamura, & Watanabe, 2002). In this cohort study, Takano et al. (2002) conducted baseline assessment of 1339 men and 1805 women, in 1992 by sending out questionnaire in mail. The questionnaire include space near the residence for taking a stroll, a park, and tree lined streets near the residence, noise from automobiles and factories near the residence, the level of crime in the community, hours of sunlight at the residence, existence of a garden at the residence, whether the residence faced a road with a regular bus service, active communication among neighboring residents, and preference to continue to live in the current community. The amount of monthly living expenses was asked, and its answer was used as an indicator of the socioeconomic status of participants. Marital status was asked, and its answer was used as an indicator of participants' living arrangements. Follow up Survival of the respondents in1997 were followed up by obtaining official residence records from their local governments. Associations between each of the baseline residential environmental factors and five year survival were examined by multiple logistic regression analysis. Independent variables of residential-environment conditions, represented by factor scores obtained by the earlier analysis, were calculated after excluding the effects of age, sex, marital status, and socioeconomic status.

First, self-report survey often is questioned on its liability, for trusting only the reporter for the result. Giving the fact that the study targeted on aging population, the health-related data collected in the baseline survey seems not to be sufficient to exclude the impact of individual's medical condition in the analysis. In addition, the study could be also improved by collecting data on the physical health condition instead of only on the survival rate in the follow up survey.

By handing out survey questionnaires to 500 urban park visitors in China, Tan&Zhao(2007) confirmed that open space experiences have a positives influence on psychological and mental health(Tan & Zhao, 2007). Publics are asked to compare the effectiveness on stress release from visiting green spaces, shopping and drinking tea, which seems to be insufficient for not including items such as going to gym, gardening or other indoor activities. The study could also be improved by add questions on the type of activities involved in visiting the green space. In addition, to connect the link between urban ecological systems and social benefits, survey questions could be added on the public opinions on certain ecological elements in the space. Many cultural services are associated with urban ecosystems and there is evidence that biodiversity in urban areas plays a positive role in enhancing human well-being. For example, Fuller et al.(2007) conducted a study that successfully combined quantitative and qualitative data by collecting bio-diversity survey data and implement semi-structured interviews with 312 green-space users in Sheffiel, UK. In the semi-structured interviews and closed-ended questions, five statements measured likelihood of recovery from mental fatigue and the opportunity for reflection, derived from attention restoration theory, eighteen statements explored emotional attachment to, and personal identity gained from, the greenspace drawn from theory and research on place(Fuller, Irvine, Devine-Wright, Warren, & Gaston, 2007). Closed-ended questions explored psychological well-being and respondents' perceptions of greenspace species richness. Well-being measures focused on greenspace as a source of cognitive restoration, positive emotional bonds and sense of identity. Responses were made on a five-point Likert scale from strongly disagree to strongly agree based on the stem question "Please indicate how much you agree with each statement about this park" (electronic supplementary material). Five statements measured likelihood of recovery from mental fatigue and the opportunity for reflection, derived from attention restoration theory. Eighteen statements explored emotional attachment to, and personal identity gained from, the greenspace drawn from theory and previous research. Factor analysis identified groups of statements measuring a single component of psycho-logical well-being. Components were interpretable as reflection; distinct identity; continuity with past; and attachment.

Continuous measures were derived by calculating each participant's average rating of the set of statements forming each component.

Sugiyama et al. (2008) conducted research to examine associations of perceived neighborhood ‘‘greenness’’ with perceived physical and mental health and to investigate whether walking and social factors account for the relationships. The study sample was drawn from residential addresses within 32 neighborhoods, each of which consists of several contiguous census collection districts. In each neighborhood, 250 addresses were randomly selected and sent a letter requesting participation in the study. One person from each address was asked to participate. Those who met the eligibility criteria (living in private dwellings, aged between 20 and 65 years, able to walk without assistance and able to take part in surveys in English) and agreed to participate were sent a survey including questions (Sugiyama, et.al., 2008) .A total of 2194 eligible participants from 154 census collection districts returned the questionnaire. The outcome measures of this study were participants' ratings of their perceived physical and mental health. From the 12-item short-form health survey (SF-12), the physical component scores (PCS) and mental component scores (MCS) were computed and examined separately. To identify the perceived greenness of a neighborhood, five questions from the Neighborhood Environment Walkability. Scale28 were used. The internal consistency (Cronbach's alpha) of the scale was 0.67. To capture the salient elements of outdoor physical activity, the amount of walking for recreation and for transport were assessed separately, using the relevant items in the long form of the International Physical Activity Questionnaire version 29.

Participants were asked to recall the frequency in the past week (number of days) and usual duration per day (hours and minutes) of these two types of walking.

To measure social coherence, participants were asked to respond to questions adapted from the Neighborhood Quality of Life Study30 were from a scale developed by Sampson RJ and Raudenbush SW, and the last three items These items were merged because they were found to form a single dimension (Cronbach's alpha 0.82).

Neighborhood safety

Troy et al. (2012) studied the association between neighborhood crime rate and tree canopy coverage. The researchers obtained crime data for Baltimore City and County from Spotcrime a service that aggregates and address geocodes crime data from public record police reports, augmented by news stories and user input. Tree canopy data in the study came from the combination of a 2007 high resolution land cover layer for Baltimore City and County, along with surface models generated from light detection and ranging (LiDAR) data. LiDAR helped for the detection of trees within areas obscured by building shadow and the differentiation of canopy trees versus low woody vegetation, like shrubbery(Troy, Morgan Grove, & O'Neil-Dunne, 2012). The smallest patch of tree canopy that could be detected using this approach was 9 m^2. The study is overall rigorous in the data collection process, giving the scale of the target area. The entire dataset was then manually reviewed at a scale of 1:2500 and all identifiable errors were corrected. The accuracy of the tree canopy data following manual corrections was assessed by random check of 150 points for areas classified as tree canopy, and another 150 sampled for areas not classified as tree canopy. The random check shows the overall accuracy of the method was 93%. Some other factors that considered to be significant confounders for crime rate, such as socio-economic status (income, race), housing type and tenure and the natural environment are controlled in the statistical analysis. In addition, the research could benefit from including more qualitative data at neighborhood scale. Asking local residents regarding the other component of the physical environment, such as walkability and quality of basic facility, which could also be confounding factors for the study.

Public perceptions of urban ecological system

Andersson(2007) attempted to answer the question: Are differences in management practices linked to the local social-ecological context of institutions, local ecological knowledge, and sense of place. The qualitative data collection include the questionnaires sent out to gardeners and community associates to identify key information and knowledge about local eco-system(Andersson, 2007). Semi-structured interviews were then carried out within selected individuals from the survey to understand interviewee's local ecological knowledge, identify key management practices and social institutions that have important implications for ecosystem dynamics, even if the linkages between these social features and ecosystem dynamics possibly was unknown to the respondents, to assess the emotional bond of the respondents to the area. Interviewees for this section include fifteen were conducted with key allotment holders, five with head managers of cemeteries, and four with managers of city parks and one head city gardener of Stockholm. It is arguable that since the interviewees are all in open space or public space management related professions, or have strong interest in it, the result might not be reliable to conclude for questions regarding local eco-system knowledge or sense of place.

Kocs (2013) used a mixed methods that included a survey instrument, open-ended interviews, behavioral and trace observations, and modified grounded theory methodology for data analysis. The purpose of the study was to identify the hierarchy of values that users of ecologically restored areas of Chicago's Lincoln Park associated with their use of the park areas and to determine the extent to which they experienced contact with nature while visiting the areas. This study falls within the framework of a post-occupancy evaluation of the restoration projects, the Lincoln Park Evaluation Study on Lincoln Park(Kocs, 2013). Kocs, as the principal investigator for the POE, developed a set of ten values or benefits associated with park use that were included in the survey instrument and informed the onsite, open-ended interviews with park users—beauty, solitude, tranquility, recreation, health, contact with nature, habitat preservation/restoration, community identity, public life, tourism, and other (to allow respondents to add their own values to the list). The values are decided on the basis of the literature review with combination of data collected previously when Kocs was working under the post-occupancy evaluation. The dissertation also comprises a comprehensive case study of ecological restoration in the park where Kocs conducted analyses within a larger case study method that has been developed for landscape architecture (Kocs, 2013). The fact that Kocs was able to collect sufficient data in preparation of this study is very beneficial in identifying the theme of research questions. However, the size of the sample, which is 80 for 4 target restoration areas seems to be too small, and the selection criteria is very exclusive for not including first time visitor and none-English speakers. That may result in the sample's lacked of socioeconomic, racial, and educational diversity compared with the broader Chicago population.

Chen (2006)'s study also include to evaluate the monetary value of ecosystem service of recreational opportunities and amenities. Data collection included the questionnaire survey, focusing on residents' willingness-to-pay for recreational opportunities and amenity of urban green spaces in Guangzhou. In addition, urban dwellers' attitudes towards urban green spaces, their knowledge of ecosystem services generated by urban green spaces, their habits of recreation and amenity activities were investigated. Based on the explanation of urban green spaces and the description of ecosystem services of urban green spaces, the questionnaire sought responses on urban dwellers' attitudes towards urban green spaces, their knowledge and recognition of the benefits and negative impacts of urban green spaces, their expectation of green spaces, their recreation activities and influencing factors, willingness-to-pay for recreational opportunities and amenity of urban green spaces, and socio-economic variables of the respondents. A pilot test (26 respondents were involved, including survey helpers, experts and local residents) were taken before implementing the full-scale survey to check the logic and understandability of the questionnaire (Chen, 2006).

About 340 randomly chosen residents living within the study area were interviewed face-to-face. A clustered sampling frame was adopted. Firstly, 34 residential blocks were chosen randomly with the help of Guangzhou Census Office, who kept basic information of all residents of Guangzhou. Then, the respondents in the chosen residential streets were randomly selected and interviewed by survey assistants. A gift was presented to each respondent as a token of appreciation for participating in the interview and to encourage respondents to give truthful responses.

Data collected through the questionnaire survey were analyzed using SPSSPC software. The statistical analysis of questionnaire response included response rate, validity of answers, residents' attitudes towards urban green spaces, their knowledge of urban green spaces, frequency, time, reason, purpose, and companion of residents' recreational activities, how much respondents have paid for using green spaces, and their willingness to pay for recreation and amenity service of urban green spaces in the built-up area of Guangzhou.

CHAPTER 5

RESEARCH QUESTIONS AND METHODS

In this chapter the four study sites are briefly described and compared. Research question and methods are described in detail.

The purpose of the research for this dissertation was to investigate the ecological, social and economic features of the selected urban ecological parks. Table 5.2 below presents the questions that guided the research and the data collection methods used. The collected data were analyzed both qualitatively and quantitatively. Survey questionnaires, interview transcripts and online reviews were analyzed through content analysis.

Table 5.1 Research Questions and Sources of Data

Research Questions	**Sources of Data**
1. What were the previous land uses of the sites?	Satellite images
2. What were the previous and what are the current demographic features of the sites?	Satellite images; Online documents
3. How did the surrounding areas change after the parks were initiated?	Satellite images; Online documents
4. What are the ecological features of the parks, and what is their performance?	Online documents; Remote sensing NDVI
5. What are the design features of the parks?	Observations of design features;
6. Who are the visitors to the parks and what do they do there?	Observations of users; Survey of users
7. What are the public responses to these parks?	Survey of users; Interview with users; Online social media reviews

5.1 Four Cases of Ecological Parks

For this dissertation research four ecological parks in Xi'an were selected for in depth study to document and analyze the ecological and social features and consequences of ecological restoration initiatives in the city of Xi'an. The four selected sites represent urban forest restoration, urban grassland restoration and urban wetland restoration of different scale.

Xi'an is the capital of Shaanxi Province, China. The city is located on the Guanzhong Plain in northwestern China. The city has an average elevation of 400 meters (1,312 ft) above sea level and an annual precipitation of 553 mm (21.8 in). The city is located at the northern foot of the Qin Mountains to the south, and the bank of the Wei River to the north. In response to the environment challenges faced by Chinese urban areas, the program of "ecological restoration, urban repair" was announced at the National Congress of the Communist Party of China to restore the "natural ecological city" according to the Ministry of Housing and Urban-Rural Development of People's Republic of China ([MOHURD], 2016), and the city of Xi'an is listed as the second group of pilot city for the implementation of the program for a new urban development pattern that aims to include the restoration of natural ecological features in urban environment. This ecological restoration initiative are being implemented at multiple scale, including regional, city level, to create green network that assist to limit future urban expansion and serve as habitats and migration routes for wildlife (for example migration birds). At the neighborhood level, the goal is to provide connections of greenway and multi-dimensional greening that permeate into the built-up areas.

The four cases of ecological parks in Xi'an, chosen for this study, illustrate four different types of ecological restoration parks (Table 5.2). The four parks vary in their dates of completion and degree of completion: partially completed, recently completed to fully complete. The sites also very by type of restoration: urban forest restoration, urban wetland restoration, and wildlife habitat restoration. The overall size of the selected sites also varies, and they vary in how they balance public use with traditional ecological restoration practices.

Table 5.2 Four Sites

Name	Restoration Type	Size	Waterbody	Neighborhood Environment	Time Frame
Chanba Wetland Park	Wetland Wildlife Habitat	1452 acre	37%	Low density residential	2013 April completio n
Xi'an Eco Park	Wetland Grassland	280 acres	11%	Residential/Commerci al	1st Phase 2019
Guodu Forestry Park	Forestry	42 acres	0%	Low income Residential/Commerci al	2019 Completed
Yanming Lake Park	Wetland	110 acres	60%	Residential/Commerci al	2016 Completed

Chanba Wetland Park

Chanba Wetland Park is a large-scale ecological restoration park that is located with some distance to the densely populated urban area. The location of the site provides the park with opportunities to meet some of the ecological goals valued by traditional ecological restoration projects, such as restoring habitat for endangered wildlife species since the site is considered located in less densely populated region. It has been reported that there are more than 150 different animal species currently inhabiting in the park, 13 of which are national endangered species(Xi'an Chanba Wetland Park, 2020). Figure 5.1 shows the aerial view of the park.

Figure *5.1* Aerial view of Chanba Wetland Park
Source: Google Earth

The area around Chanba Wetland Park consists of farmland and scattered low density residential buildings. Because the site is relatively remote from city center, the park is not directly pedestrianly connected to a residential or commercial neighborhood. Currently the park is primarily accessed by motor vehicles. Designated parking spaces are provided for visitors. Figure 5.2 diagrams the important features of Chanba Wetland Park's surrounding environment.

Figure ***5.2*** Chanba Wetland Park's surrounding environment
Source: Google Earth

The Chanba Wetland Park is separated into four sections: an ecologically preserved area, a wetland eco-tourism area, and an agriculture and fishery and management area. The ecologically preserved area serves are the core of the park. This area is primarily preserved for research purposes with limited public access. The infrastructure in the preserved area is designed to minimize human impact on the ecological system. Areas that are home to endangered animal species have no public access, while areas designated for migrating birds are temporarily closed for nesting purposes. The ecologically preserved area has a buffer zone surrounding it to manage the human impact. The buffer zone is heavily vegetated. The wetland eco-tourist area is the landscape asset and is fully open to the public. The Park also offers recreation opportunities where people engage with features of the park: a u-pick orchard and designated fishing zones. The fourth of the park is the management area that provides visitors with services such as tourism introductory, public restrooms and educational program services. Figure 5.3 is a view into of one of restored wetland area.

Figure 5.3 View of the wetland area in the Chanba Wetland Park

Xi'an Eco Park

Xi'an Eco Park is a 280 acre "L" shaped urban ecological park located in the south part of the city. The park is bounded by major highways with the Zao River crossing the site. One of the primary goals in the development of Xi'an Eco Park's was to restore a healthy hydrological cycle supported by that river. The idea is to bring storm water to the river the storm season and to utilize that to irrigate vegetation in the park in the dry season. Figure 5.4 Aerial view of Xi'an Eco Park shows the aerial image of the Xi'an Eco Park and surrounding area.

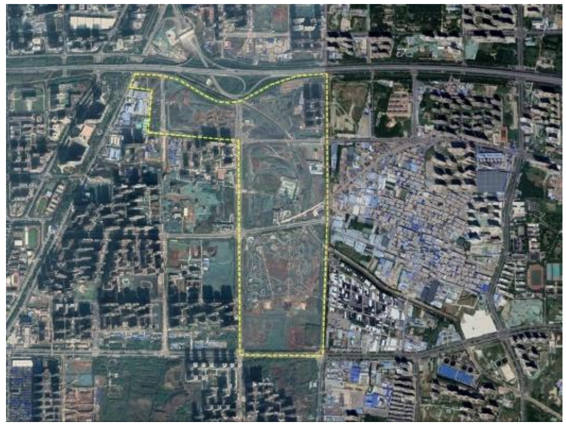


Figure 5.4 Aerial view of Xi'an Eco Park
Source: Google Earth

The entire district has many newly constructed residential complexes or ones under construction. Since some of the area is undergoing transformation from informal housing blocks to brand new residential/commercial development, the immediate surrounding neighborhood is not as densely compacted as the neighborhood in the distance. One elementary school and one kindergarten are located within 0.5-mile distance to the park. Figure 5.5 diagrams the site and the important features of the neighborhood around it.

Figure 5.5 Xi'an Eco Park neighborhood environment
Source: Google Earth

The park is separated into five sections distinguished by function: urban front area, wetland, ecological restrained area, sports zone, and service area. Circulation around and within the park is designed to separate pedestrians from, vehicles The pedestrian circulation is also facilitated by walkways above the ground plane to preserve the ground level vegetation while providing views of the park. This park's design was challenged by historical preservation of ancient city relic laying underground, which posted limitation on vegetation selections, therefore the phase one part of the park is mostly covered by plants with shallow roots. The vegetation design of the park still follows the principles of using native plant species and providing diverse vegetation., The goal is to a diversity of plants as a group, instead of a proliferation of a single type of individual plant. Figure 5.6 shows walkway with grass growing around it.

Figure 5.6 Xi'an Eco Park pedestrian walkway

Guodu Forestry Park

Guodu Forestry Park is a small-scale urban park of 42 acres. As indicated in its name, the ecological objective of this park is to increase forestry coverage, in order to provide shading and climate regulation in this densely populated area. Figure 5.7 shows an aerial view of Guodu Forestry Park.

Figure ***5.7*** Aerial view of Guodu Forestry Park
Source: Google Earth

The triangle shaped park is bounded by highways on three sides. This park is surrounded by residential high rises and commercial buildings. The residential/commercial blocks to the west side of the park are relatively lower income compared to the other parks in this study. The commercial sector on the east side of the park is dominated by manufacturing business, such as factory for building materials and furniture manufacturing shops. The land use context of Guodu Forestry Park is comparably lower end. Figure 5.8 shows the important feature in Chanba Wetland Park's neighborhood environment.

Figure *5.8* Guodu Forestry Park neighborhood environment
Source: Google Earth

Guodu Forestry Park is dominated by shade trees in the south part of Xi’an city. Because the site does not have a body of could a self-maintaining hydrological cycle, maintaining vegetation in the park has been difficult. One common problem related to forestry restoration is that, after the shade trees reach maturity, the rich canopy they create can limit the amount of sunlight that reaches the vegetation underneath. Therefore, planting of low vegetation has been limited. Also due to the small size of this park, the variety of outdoor furniture is also limited. Figure 5.9 shows the pedestrian walkway underneath the heavy shade tree canopy.

Figure *5.9* Guodu Forestry Park walkway underneath the shade trees
Source: Google Earth

Yanming Lake Park

Yanming Lake Park is a 110-acre ecological park that centers one restored retention lakes. Design and constructed in 2015 and 2016, the park are approximately 3.8 miles long and 0.3 mile wide. About 60% of the park is covered by water, the remaining is vegetated or paved.

The ecological objective of this project is to restore a healthy wetland system to enhance the hydrological systems that go through and around the city. The wetland area and upland forest in the park are intended to provide habitats for migrating birds. Figure 5.10 is area aerial image of the Yanming Lake Park and surrounding area. The park offers open waterfront walkways with the social objective of creating public space for leisure activities.

Figure 5.10 Aerial view of Yanming Lake Park.
Source: Google Earth

Yanming Lake Park surrounded by several residential complexes close to the park, giving the public direct, walkable access to the park. It also has two parking lots located at the north and south ends of the park. The adjacent neighborhood of the park includes mixed use (residential and commercial) complexes and two elementary schools. The residential complex around Yanminghu Park is on average high-end including some single-family luxury houses. Figure 5.11 diagrams the site and the important features of the neighborhood around it.

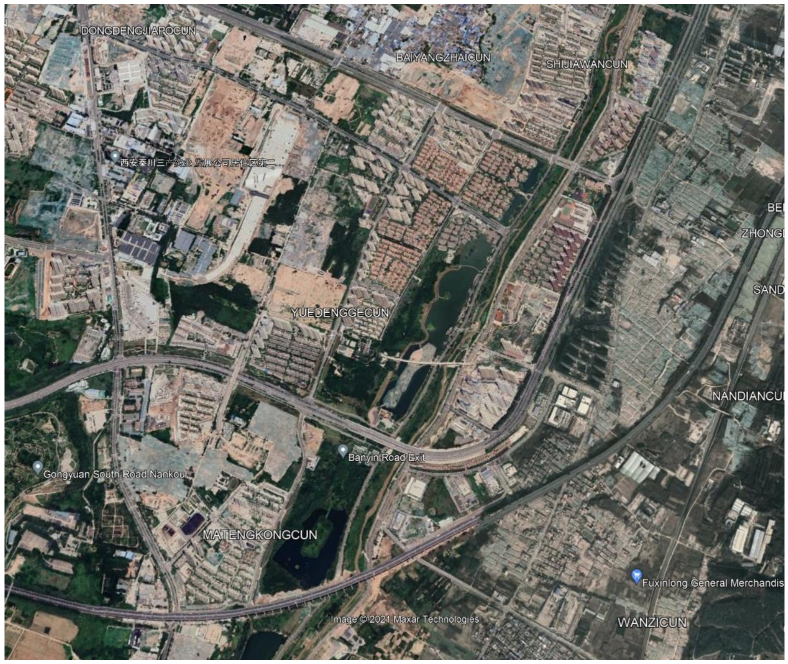


Figure 5.11 Yanming Lake Park neighborhood environment.
Source: Google Earth

The ecological features of this park include: a restored wetland area, one vegetated upland forest island at the center of the park, and two other smaller vegetated islands. The waterfronts of the park are paved with a plastic trail. Bridges over the water provide access to the vegetated islands. This park is equipped with various kinds of outdoor furniture and sculptures. Figure 5.12 shows the wetland and the upland forest from the waterfront walkway.

Figure 5.12 Yanming Lake Park wetland and upland forest.

5.2 Research Methods

In order to collect information about what visitors do in the parks and how they feel about them, three methods were used: field observations of the number and actions of visitors, a survey of visitors, personal interviews with some of those same visitors and information collected online from dianping.com; ctrip.com; mafengwo.com; meituan.com. To collect information on the site features, design/built conditions and vegetation conditions of the site, the three methods used includes: field observation of the design features, google earth image and Normalized Difference Vegetation Index (NDVI) processing using Geographic Information Systems (GIS).

Information about each of the sites including user counts, stationary activity counts, and the quality and condition of design elements were collected during site observations. Pre-prepared checklists are used for both user observation and documentation of design elements. User counts were used to measure volume of visitors in each park. Stationary activity scans will track the number of different activities in pedestrian plazas. In this instruments, stationary activities included the following seven activities: eating/drinking, chatting, dancing, electronic device, commercial, and other. These activities and postures were counted regardless of headcounts. For instance, one person can eat, chat, and use an electronic device while sitting, standing, and leaning during the period in the plaza. In this case, I recorded each activity and posture independently. Checklist for user observation is available in Appendix C. Data regarding use of the sites by the public was collected primarily through on-site observations, during the period of spring 2019 to summer 2020. Apart from user observation, the study of public use is supplemented by a selective photography method. While walking at regular pace, the investigator took 360° panorama pictures using a digital camera for every 60 seconds. The advantage of this method is that the observer did not need to decide what to photograph on site. Also, taking panoramas is less intrusive than taking pictures of activities directly. Panorama pictures were analyzed to investigate public use and users. Data on the locations of users and the uses associated with the site features was also collected from the pictures. The total number of observations are recorded, percentage of each activity is calculated and presented in Section 6.2.

On-site surveys with users were conducted following each on-site observation to understand who the users are and how diverse.Participants were asked about basic demographic characteristics, means of transportation to the site, whether they live locally and their impression of the design of the park. A total of 79 people were surveyed at all four sites: 43% female and 57% male.

Additional interviews were conducted with frequent visitors who have more knowledge about the park. Interviews were also conducted with landscape maintenance crew and security staff. Seven staff on sites were interviewed in four sites: three landscape crew, four security staff. Questions were asked about the maintenance workload and their responsibilities on site. All interviews were conducted by student investigators or trained research assistants.User survey and interview checklist is available at Appendices A and B.

Data about ground surfaces, wildlife, vegetation, and vertical structures were collected by onsite observers using a prepared checklist (see Appendix D). Research assistants were instructed to visit each of the four sites and document the site features following the sequence of observing. For each type of ground surface, the material, the permeability, and its intended use of the ground surface is documented. Since the intended use of every ground surface type is categorized into circulation, gathering and special uses.

On-line data became a key source of data during the winter of 2020 due to COVID-19. Several online data mining strategies were employed for retrieving information regarding public responses and uses of each park. Large amounts of data about the public's responses were collected from social media and review websites such as Dazhong review, Meituan and Xiecheng. The total number of 1005 comments are collected from these social media websites (Chanba Wetland Park:201, Xian Eco Park:459, Guodu Forestry Park:45, and Yanming Lake Park: 300). The comments went through content analysis, terms of interest are recorded and counted. Since the social media comments are all open ended, the frequency of the mentioning of similar terms are counted accumulative.

Remote sensing data collection and analysis in this study include the land cover type survey based on google map, and the 30 meters Normalized difference vegetation index (NDVI) data retrieved from the Resource and Environment Science and Data Center in Institute of Geographic Science and Natural Resource Research, CAS.

Google earth area images of the four sites are coded based on the color and pattern of the surface observed in the ariel image. Nine different surface types are determined: lawn, shrubs, shade trees, buildings, gathering spaces, vehicular lanes, pedestrian walkway, waterbody, and others (see Figure 5.13). The 2020 August google ariel image are coded and transferred into Arch GIS 10.1 for area calculation, to determine the area sum of each type of surface in four of the parks, respectively.

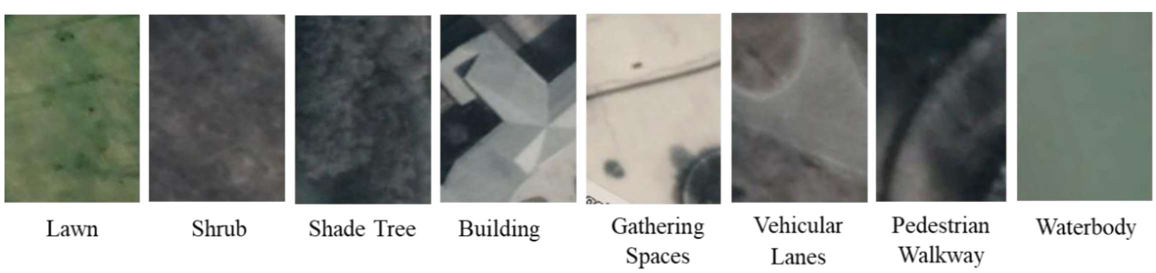


Figure 5.13 Land cover classification reference image.

The raw 30 meters NDVI data are at the scale of entire Shanxi province. The data is first processed to show the area of the four parks. The cells sized 30 meters by 30 meters that fall within the site boundaries are extracted. The values of NDVI of year 2000 and 2020 are compared. The comparison is made through visual representation with the value scale from 0 to 1. The statistical analysis over the distribution of that 2000 NDVI and 2020 NDVI are compared using one-way Anova.

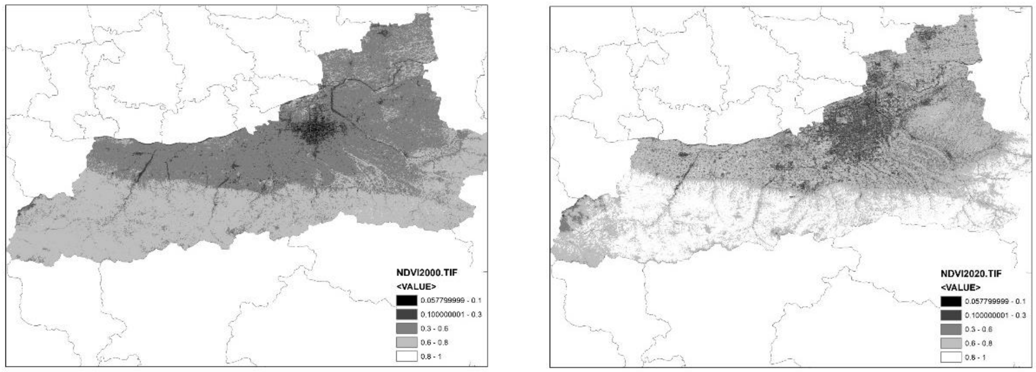


Figure ***5.14*** Thirty meters Normalized difference vegetation index (NDVI) data for Shaanxi Province in 2000 and 2020.
Source: Resource and Environment Science and Data Center in Institute of Geographic Science and Natural Resource Research, CAS

CHAPTER 6

FINDINGS AND DISCUSSION

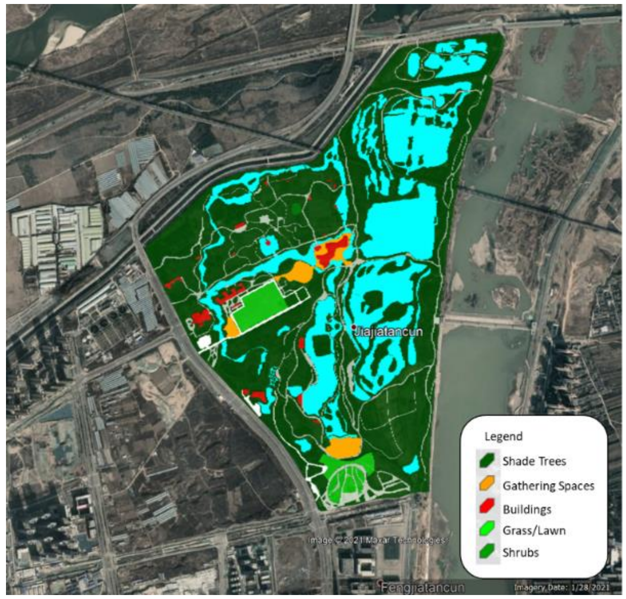
This chapter presents findings from comparing the four selected sites though their design and planning features, users and uses, and maintenance and management strategies. Details about each element and how do they incorporated within each other to facilitate ecological restoration park as an innovative type of public space is discussed.

6.1 Design and Planning

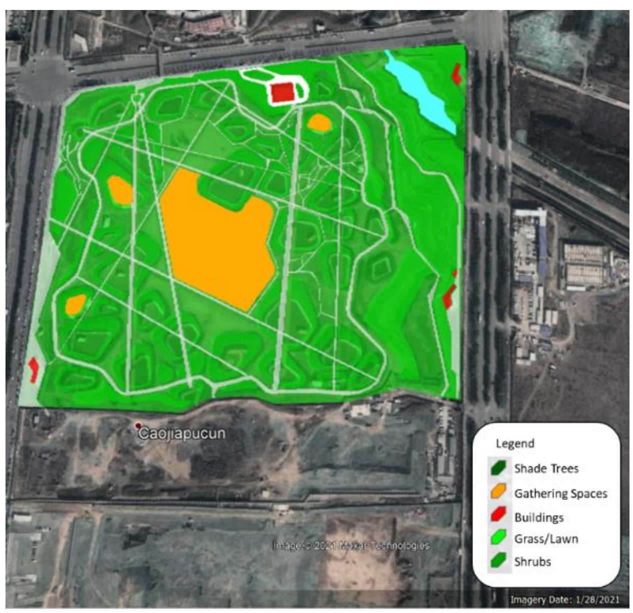
Design elements such as entry and edge, pathways, ground surfaces and amenities differentiate ecological restoration parks from traditional public spaces in terms of providing access and use. Planning vegetation and wildlife differentiates ecological restoration parks from traditional ecological restoration projects. Also, the design and planning strategies for ecological parks also emphasize the health of ecosystems, which is not true for traditional public spaces. This chapter presents the findings about the key design and planning features of the ecological restoration parks studied regarding land use, entry and edges, pathways, ground surfaces, amenities, vegetation, and wildlife.

6.1.1 Land Use

The land cover of each of the four sites are studies and categized into the following components: lawn, shrubs, shade trees, buildings, gathering spaces, vehicular lane, pedestrian walkway waterbody and others. Figure 6.1 visualizes the land cover types of the four sites. The area of each polygon that represents different land cover types are calculated then sum up to the total acreage of each type using GIS.



(a) Chanba Wetland Park



(b) Xi'an Eco Park

(c) Yanming Lake Park

(d) Guodu Forestry Park

Figure 6.1 Types of land cover in four study sites.

Table 6.1 summarize the land use of the four study sites. The result shows woodland restoration is heavily emphasized in all four parks regardless of the initial established restoration goal. Woodland is commonly considered with high ecological values in functioning including carbon sequestration and climate regulation. More specifically for individual types, shade tree coverage is heavily emphasized in four parks. All four sites have high shade tree percentage ranging from 25.7% to 87.2%.

The total percentage of land that is unbuilt, which includes lawn shrubs shade trees, waterbody combined is significantly higher than that of built area, which include, buildings, gathering spaces, vehicular lanes, pedestrian walkways combined in all four parks (shown in Table 6.2). Guodu Forestry Park shows the lowest built area percentage of 9.8%, while Xi'an Eco Park show the highest built area percentage of 23.5%.

Table 6.1 Types of Land Cover

Name	Lawn	Shrubs	Shade Trees	Building	Gathering Spaces	Vehicular Lane	Pedestrian Walkway	Waterbody	Others	Total
Chanba Wetland Park	2.9%	0.1%	60.1%	1.3%	1.8%	1.1%	6.0%	26.7%		100%
Xi'an Eco Park	33.7%	15.6%	25.7%	0.6%	8.1%	0.7%	14.0%	1.4%		100%
Guodu Forestry Park		3.0%	87.2%	0.3%	1.6%		7.9%			100%
Yanming Lake Park	10.3%	0.1%	48.5%	1.0%	1.5%	3.6%	5.0%	29.3%	0.8%	100%

Table 6.2 Land Cover (Unbuilt vs. Built)

Name	Unbuilt	Built	Total
Chanba Wetland Park	89.8%	10.2%	100%
Xi'an Eco Park	76.5%	23.5%	100%
Guodu Forestry Park	90.2%	9.8%	100%
Yanming Lake Park	88.2%	11.8%	100%

All four parks underwent land use changes through the process of re-constructing ecological system that is very different from previous system of the sites. Figure 6.2 shows the comparison of land uses between year of 2000 and 2020 within four parks. Before becoming heavily vegetated parks or wetland parks like today, three of the four sites selected were previous has intensively managed agriculture system with produce including mostly wheat and/or corn. Guodu forestry park is the one exception, it was a barren land that is sitting in the triangular shaped left-over piece bounded by roadways on three sides.

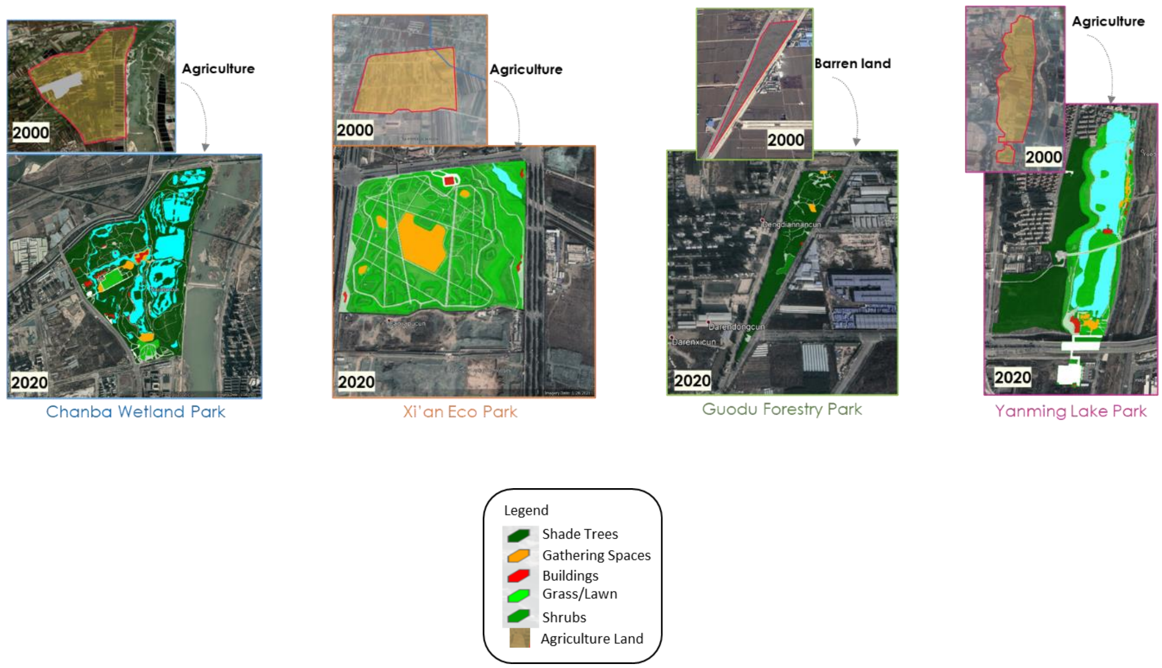


Figure 6.2 Land use change from 2000 to 2020 in four study sites.

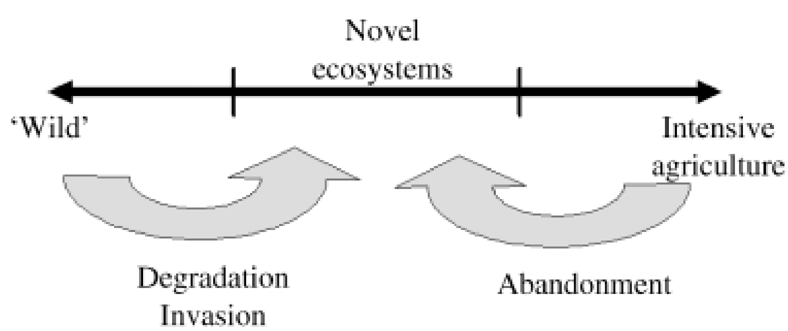
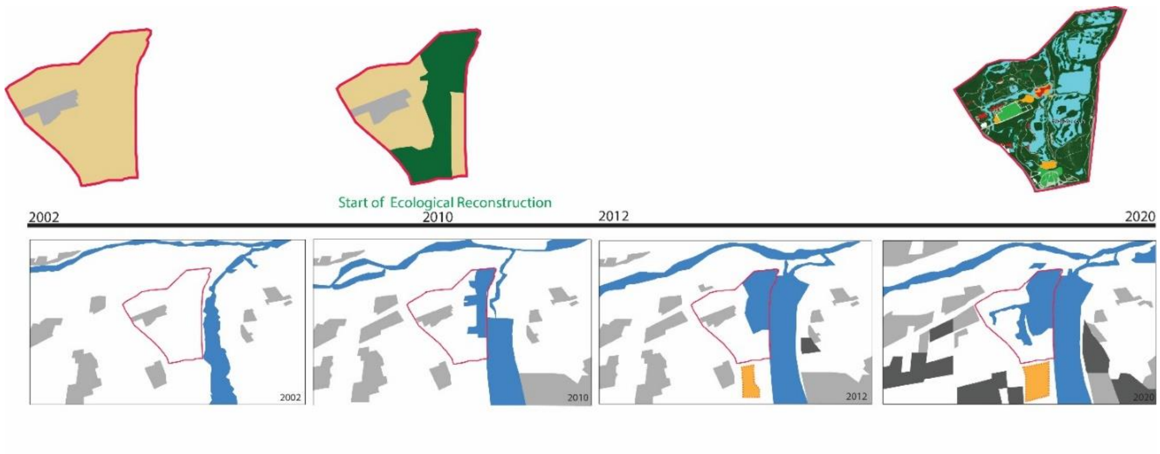


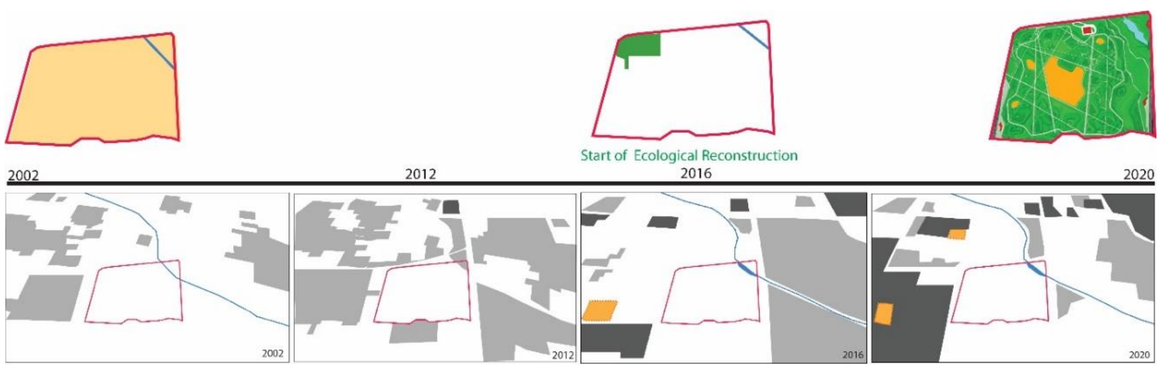
Figure *6.3* Novel Ecosystems as a zone in the middle of "wild" and intensive managed systems.
Source: Hobbs, R. J., Arico, S., Aronson, J., Baron, J. S., Bridgewater, P., Cramer, V. A. & Zobel, M. (2006). Novel ecosystems: theoretical and management aspects of the new ecological world order. Global ecology and biogeography, 15(1), 1-7.

This kind of land transformation is characterized in the form of new vegetation species combinations and changes in ecosystem functioning, and the role of human agency. Which fits what Richard J. Hobbs and his colleagues described as novel ecosystems(Hobbs et al., 2006). These types of ecosystems can be thought of as occupying a zone somewhere in the middle of the gradient between 'natural' or 'wild' ecosystems, on one hand, and intensively managed systems such as agricultural land on the other hand (Figure 6.3). Three of the sites are observed to going through the process of withdrawing the intensive agricultural management practice with homogenous vegetation type and transformed into a more complex hydrological and vegetation system that emphasis biodiversity and landscape diversity.

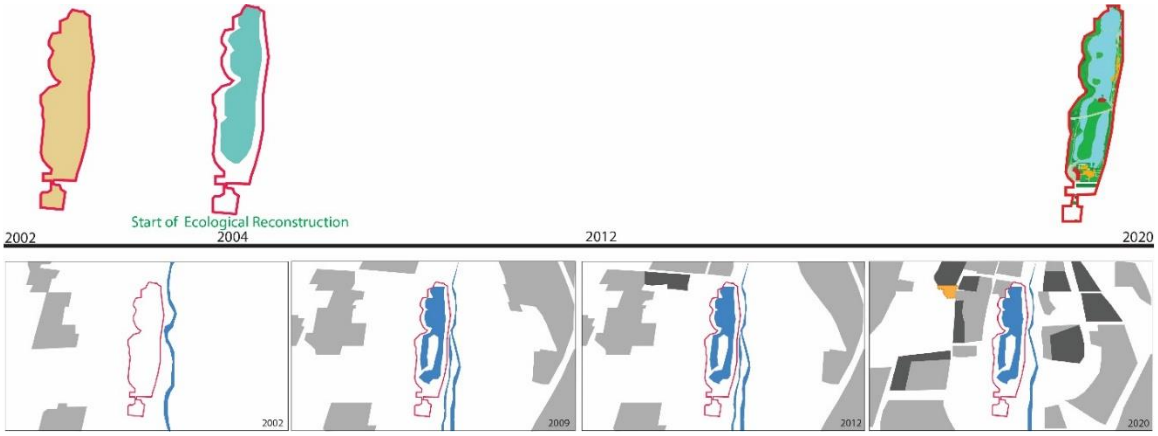
With the help of historical aerial images, in addition to the study of land cover change within each of the site, the changes of built vs. unbuilt development was also mapped out. In Figure 6.4, the timeline of each park is presented with 10-year increment. Above the centerline show the key moment of initiation of park project, below shows the key monuments in land transformation around the site. It is notable that following the initial implementation of the ecological parks, development starts to emerge and intensify around. Due to the mix development pattern in the area, it is difficult to predict whether development is commercial or residential. The mapping of neighborhood land cover also shows that ecological restoration sites are becoming center elements in facilitating the development around their immediate surroundings, which is result of both state level planning strategies and the parks influence over the local housing market. Among the emerged development, schools are shown to emerged alongside the initiation of park development in all four parks.



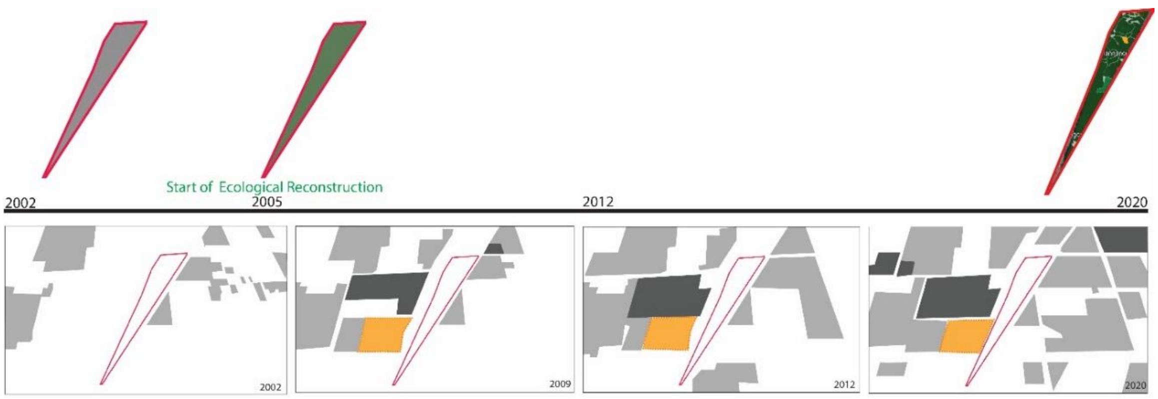
(a) Neighborhood changes around Chanba Wetland Park



(b) Neighborhood changes around Xi'an Eco Park



(c) Neighborhood changes around Yanming Lake Park



(d) Neighborhood changes around Guodu Forestry Park

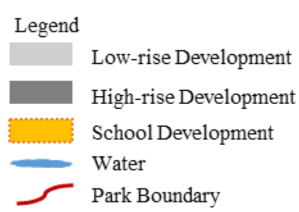


Figure 6.4 Timeline of neighborhood development changes around four sites.

(a) Four Residential Development Selected around Chanba Wetland Park

(b) Three Residential Development Selected around Xi'an Eco Park

(c) Three Residential Development Selected around Guodu Forestry Park

(d) Six Residential Development Selected around Yanming Lake Park

Figure 6.5 Residential development selected for study around the four parks.

Table 6.3 Housing Prices of Neighborhood Development Around the Parks

	Name of Development	2018/12 Price(RMB/m^2)	2019/09 Price(RMB/m^2)	2020/09 Price(RMB/m^2)	2021/09 Price(RMB/m^2)
Chanba Wetland Park	Xi Hang Garden	7942	7246	7223	8206
	Lu Gang Bin Bay	10507	9562	10147	15590
	Chengong Shuanghe	8813	9234	9787	8893
	Tian Cheng Qiang Wei		15137	12854	13215
	Avg.	9087.3	10294.8	10002.8	11476.0
Xi'an Eco Park	Nan Shen XinYuan	8090	8683	9044	9474
	Jianglin New Town D	9304	9572	10000	11278
	Jin Di Xi Feng II	14676	15803	19560	16131
	Avg.	10690.0	11352.7	12868.0	12294.3
Guodu Forestry Park	Zaoan Lingzhuang	12198	13089	15221	17816
	Jin Dui Cheng	10103	8061	6896	6896
	Lingyun Xinyuan	9748	11359	10829	13799
	Avg.	10683	10836	10982	12837
Yanming Hu Park	Yanming Shuyu	20411	20071	23206	21072
	Lvdi International II	30324	30973	35302	40107
	Lvdi International III	14099	14294	16772	20689
	Wuhu Mingdi	15154	16229	17146	19974
	Gaoke Luwan			13080	18144
	Avg.	19997.0	20391.8	21101.2	23997.2
Xi'an Avg.		12207	12635	12618	13847

Data Source: anjuke.com

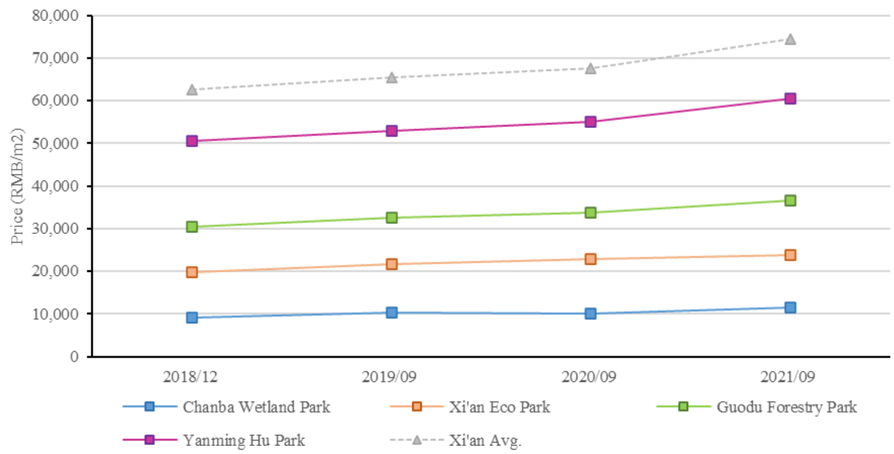


Figure 6.6 Trend of average house market price (RMB/m^2) around four parks comparing to city wide average.

To investigate the impact of the parks over the surrounding residential development, the housing price (RMB/m2) is collected and analyzed from the surrounding of four parks. The total number of 16 development community is selected (Figure 6.5), and the price from December of 2018 till September of 2021is summarized in Table 6.3. When I looked at the average housing price among residential development around the four parks, the change of price seems to be following the overall city wide average (Figure 6.6), which shows the development, started to cluster around the sites, however the housing value has been stable. Again, these are still pretty recent development, a more long-term study might be needed to be able to capture the reaction or attitude of the market. In addition, there are many differences between China and U.S. real estate market. For example, one of them is market driven another one is top-down planning driven, the housing market is tightly monitored and controlled at the state level by the government. Also due to the land ownership system in China, residents who owns the house or apartment does not own the land, the detachment of house value and land value means that the housing value measurement through the western perspective might not apply.

6.1.2 Entry and Edge

The design features of entry and edge determine the degree of visual and physical accessibility of the site and how welcoming it is to visitors. Accessibility is measured in two ways. First, how physically accessible, and how welcoming the site is to visitors when they can access the site. Second, how visually accessible the site is when physical access is not possible. Table 6.4 Entry and Edge Conditions at Four Sites shows entry and edge conditions of the four study sites.

Table 6.4 Entry and Edge Conditions at Four Sites

Name	No. of Pedestrian Entrance	No. of Vehicular Entrance	No. of Designated Parking	Boundary Define Features
Chanba Wetland Park	2	3	3	Highway Waterway Pedestrian
Xi'an Eco Park	10	0	2	Highway Waterway Pedestrian
Guodu Forestry Park	6	0	0	Pedestrian
Yanming Lake Park	9	1	2	Highway Waterway Pedestrian

Signage at the entrance is key to entry and navigation by visitors. Entrance signage should be easy to notice and informative for intentional visitors, that is those who have already decided to visit, and might have already developed their own expectations for this type of space. This type of visitor already has some understanding of what the site is, at least by reading the signs, and decides they are interested enough to visit. At traditional ecological restoration projects, where visiting by the public is not a goal, sometimes it is not possible to put up clear signage because of the large size of the project. It is also common that the site is connected to a much larger system, such as a larger waterway, making it difficult to define any boundary or any entrance. Three of the four ecological restoration parks in this study display clear entry signage, showing the intention of encouraging public access. Guodu Forestry Park does not have prominent entry signage and it is bounded by highways roads with multiple entrances into the site.

The type of boundary enclosing the park and features of the entries also determine their accessibility. Four types of boundaries are evident in the four sites: concrete walls, changing landform, roadways and waterways. If one goal is to restore vegetation or wildlife, a closed boundary, such as physical walls, makes it easy to maintain and to reach this goal. During the early stages of restoration, while plants are young, frequent maintenance is necessary to ensure a satisfactory survival rate. Full walls limit public access, protect species that are sensitive in their pre-mature condition. The establishment of walls is effective to reach that goal at small scale restoration projects. Xi'an Eco Park, although planned to eventually have a fully open boundary, was walled off at earlier stages of the project.

All four sites in this study shows efforts to open physical access through the boundary designs. Open physical boundaries observed in the four parks including: fully physically opened edges, partially opening through highways, partially opening through walls and bridges over waterways allow vehicle or pedestrian access into the sites either throughout the boundary or at particular locations. Physical access allows visitors to walk into the site and have close contact with key elements of the ecological system such as vegetation and animals. Having more access points or a complete open edge provide opportunities for people to visit by accident and not just by intention Boundary that restrict physical access while still providing are also possible. For example, in Chanba Wetland Park, the combination of low grass planting and special edge railings enable visual access to the one of the physically restricted wetland areas. In Xi'an Eco Park, even though physical access is restricted by elevated landform, visitors still have visual over the planted area in the park from outside. Similar visual access is achieved through the establishment of upland forest in Yanming Hu Park. Figure 6.7 shows the images of entry and edge conditions of the four parks discussed above.

Figure 6.7 Entry and edge conditions of the four parks.

In studying of the physical accessibility of each site, it is also found that due to the need of maintaining the ecological goal at certain location of the site. Physical boundaries are defined to prevent physical access within the site; however, many strategies allow visual access to the protected area. In Figure 6.8, shows design strategies include restored vegetation separated by water; restored vegetation in uphill area, pathway curved into restored grassland area; elevated walkway; walkway into restored wetland with glass railing; restored area separated by railing and grasses; restored vegetation separated by wire railing; restored vegetation bounded by benches. All these shows the intention of creating more open relationship between ecological protected area and public spaces through visual connectivity, that are not seen in many traditional ecological restoration projects, where people are characterized almost as “invasive” and isolated.

Figure 6.8 Design strategies that give visitors visual access while restricting physical access.

6.1.3 Pathways

In traditional public spaces circulation routes allow people to navigate throughout the site and pursue other activities as they please. In contrast, traditional ecological restoration parks seldom have any designated paved routes or paths at all in the park; these parks are completely off limits to users in order to prevent any human interference with the park. In other ecological restoration sites only motor ways are provided for designated tours, such as Fresh Kills in New York City. The Ecological restoration parks studied in this research, on the other hand, have many different types of circulation strategies, as summarized in Table 6.5 Pathway Strategies in Four Study the materials and uses employed in these particular circulation strategies are presented in Section 6.1.4.

Table 6.5 Pathway Strategies in Four Study Sites

Name	Service Vehicular Roads	Regular Vehicular Roads	Ground level Walkways	Ground level Running Tracks	Elevated Walkways
Chanba Wetland Park	√	√	√		√
Xi'an Eco Park	√		√	√	√
Guodu Forestry Park			√		
Yanming Lake Park	√		√	√	√

Other than the very basic ground level walkway, in the ecological restoration parks studied in this research, it was common to see elevated walkways that provide physical access through the park and visual access to the restored vegetation area areas without users disturbing the vegetation or any wildlife. Three of the four sites studied are equipped with elevated walkways: Xi'an Eco Park, Yanming Lake Park, Chanba Wetland Park. In Xi'an Eco Park, the elevated height of the walkways varies from about 0.8 ft. to 15 ft. For example, an elevated pedestrian boardwalk provides visual and physical access to the restored native grassland area in Xi'an Eco Park, which is also is intended to avoid fragmentation of animal habitat. Elevated routes accommodate the free movement of wildlife beneath and around the walkway and e the healthy growth of vegetation. Figure 6.9 also shows the view to the erosion control area in Xi'an Eco Park from the 15 ft tall, elevated walkway. The height of the walkways varies: low ones accommodate small animals to move beneath the walkways and higher ones allow for healthy growth of vegetation underneath with sufficient exposure to sunlight.

Figure 6.9 View from the elevated boardwalk to the erosion control area in Xian Eco Park

Pathways that cut into the vegetated area are also observed, for example shown in Figure 6.10, the 4ft wide pedestrian pathways allow circulation into the natural area, which bridges the preserved area and its urban neighbors. No circulation strategies that support means of transportations other than vehicles were observed in any of the parks. Designated bike lanes were not provided, although people were observed traveling on variety of wheels including bikes, wheelchairs, skateboards, and more on the walkways designated for pedestrian (See Section 6.2 for the use of different types of wheels by visitors.) Designated running tracks are provided in two of the sites: Xi’an Eco Park and Yanming Lake Park.

Figure 6.10 Pathways carved into grassland in Xi’an Eco Park.

6.1.4 Ground Surface

Ground surface is one of the most basic design elements for facilitating circulation in cities. Urban ground surfaces vary in material, pattern, color and texture, all of which indicate the intended uses of urban public spaces. Aside from the visible aspects of urban ground surfaces, there are also many invisible factors that could characterize the surfaces. People perceive theses ground surface through vision and through the sense of touch as they move through the city on foot or via vehicles. The ground surface of roadways, sidewalks and squares engage users not only by virtue of their appearance but also by virtue of the feelings they have as they walk drive bicycle, or skateboard on them.

In this study a 33 different type of ground surface were identified that all have the design intention to support vehicular or foot traffic. A summary of types of ground surface, types of materials used and other properties in the four study sites are is shown in Table 6.6.

Table 6.6 Summary of Ground Surface Types in Four Study Sites

Name	No. of Ground Surface Types	No. of Permeable Surface Types	No. of Non-Permeable Surface Types	No. of Material Types	No. of Types Used for Circulation	No. of Types Used for Gathering
Chanba Wetland Park	9	6	3	4	6	3
Xi'an Eco Park	8	5	3	6	4	5
Guodu Forestry Park	4	0	4	3	2	1
Yanming Lake Park	12	4	8	5	11	1

Figure 6.11 presents visual images of the types of ground surfaces observed in four parks. Nine types are observed in Chanba Wetland Park; eight types are observed in Xi’an Eco Park; four types are observed in Guodu Forestry Park; twelve types are observed in Yanming Lake Park.

Figure 6.11 Types of ground surface.

The type of surface of the pathways that supports accessibility also affects the social and ecological functions of the pathways. The size, width and paving materials of the pathways determine the types of activities people can pursue. Long, narrow, linear paths tend to be suitable for people to walk alone or with a few others but not for group activities. Platforms of large, paved areas support group gatherings and activities such as dancing or roller skating. Group dancing is a very popular activity in traditional parks in China and now this activity is accommodated in some ecological restoration parks. With the frequent use of different transportation technologies, children (and young adults) travel and play together, using wheeled or electric vehicles such as bicycles, strollers and skateboards, which they can do on paved pathways.

Lawns, although not a very sustainable option, are the most popular areas for free activities such as soccer, picnics and kite flying in the ecological restoration parks. Ground surface materials influence how the how the space can be used for different activities. Relatively soft materials like synthetic rubber allow for running and other ways of exercising. Smooth, hard surfaces such as asphalt or concrete are good for visitors using strollers, scooters, skates, wheelchairs, bikes, and for runners and even dancers.

Figure 6.12 shows the number of different types of ground surface categorized by the material uses. Stone and bricks are the two most frequently observed materials. They vary in color and layout patterns, although sometimes they feel similar when touched. Stones are harvested from rivers or mountains; bricks are manufactured through firing and casting processes. The stones vary in color and geometry, while bricks surfaces vary mostly by their layout patterns.

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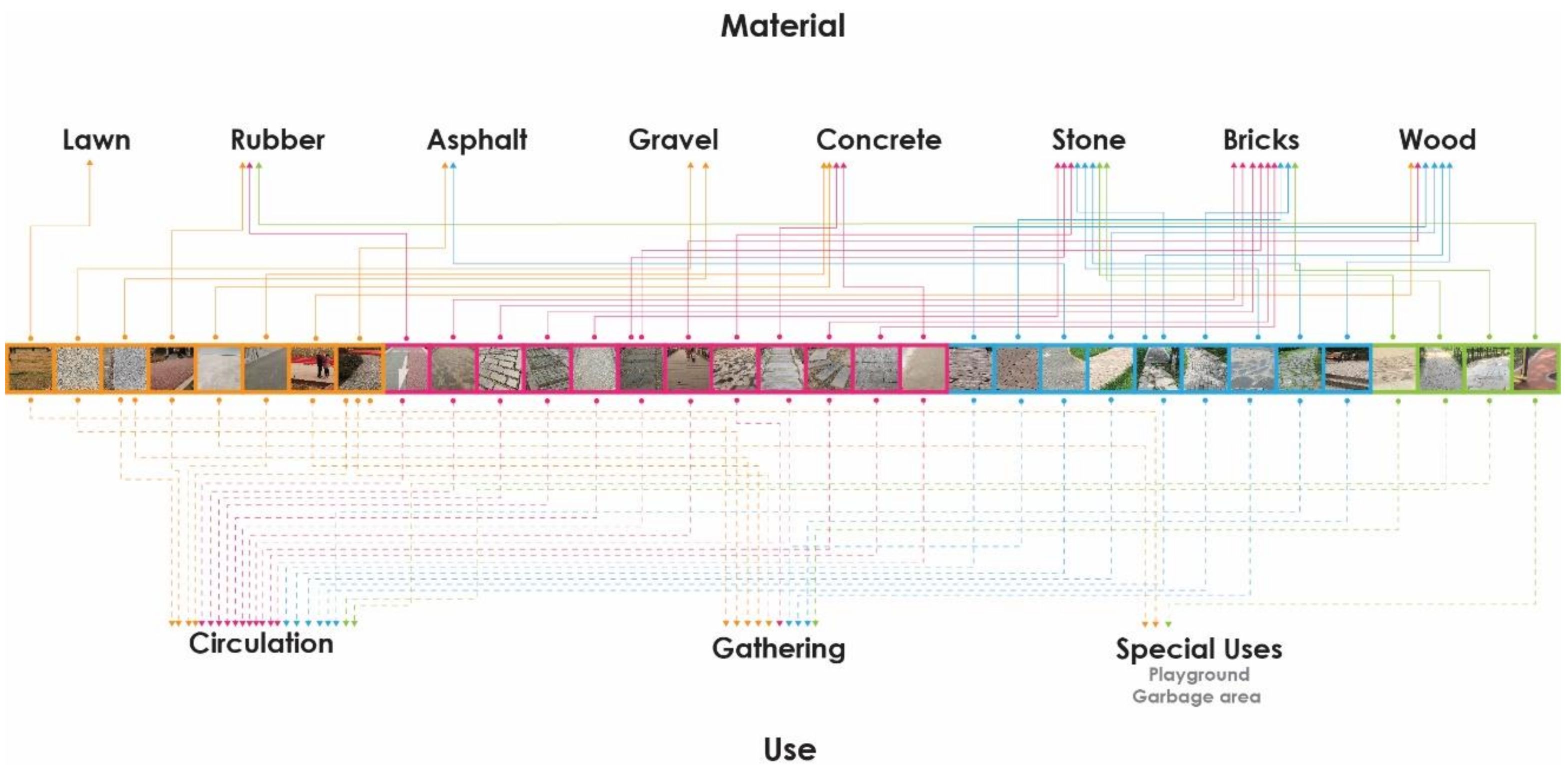


Figure 6.12 Materials and uses of ground surface.

The type of ground surfaces also affects the ecological performance of the site. The most obvious way it does so is the perviousness of the surface, which is important for storm control, ground water recharge and water conservation. To study the types of ground surface at a given site and to measure permeability, it is necessary to identify the surface materials and installation patterns. In this research on-site testing was conducted to verify the permeability of surfaces. Water was poured onto the ground surface at a variety of locations in order to observe how quickly the water was absorbed. The results of this method are shown in Figure 6.13. The results indicate that most of the ground surfaces used by pedestrians in the parks are non-permeable. Permeable surfaces were observed only at the parking lot of Chanba Wetland Park and on some wooden walkways that have space between boards. In Xi'an Eco Park permeable concrete is used for the ground level pedestrian path, but not for the elevated walkways. Permeable surfaces result in uneven surfaces that pose challenges for handicapped visitors, people with baby strollers, or high heels as well as for skaters and bikers.

Across the four sites, there are more types of non-permeable surfaces comparing to permeable ones. The number of non-permeable surface types at the four sites studied surpass that of the permeable surface type, since the ecological restoration parks studied also have plentiful vegetated surfaces filled with soil, the hydrological cycle may already be optimized. Therefore, permeability at the entire site level is achieved. Permeability of surfaces can be achieved both by the material that is used (for example the new type of material such as permeable asphalt) or more commonly observed to be achieved by the pattern of the material being used, leaving gaps between stones, casted bricks, or wooded boards, these all make the surface porous because the way the material is layout, not because the material itself. For the same type of materials that has similar sense when touching it, the level of permeability varies. For example, the Rubber sidewalk/running track, or the bouncy surface used in one of the playground areas, some of them are allow water to infiltrate very quickly but some do not. It is also observed that even some surfaces are design to be permeable, the property of the paver itself or the soil underneath has changed, which reduced the rate for water to penetrate through. Figure 6.14 shows example of a ground surface type observed in Yanming Lake Park with slow penetration rate due to compacted soil and inefficient distribution of brick layout.

Figure 6.13 Permeable vs. non-permeable surfaces in four sites.

Figure 6.14 Permeable pattern with very slow penetration rate due to compacted soil.

6.1.5 Amenities

Amenities such as furniture, public bathrooms and sculpture are uncommon in traditional ecological restoration projects since accommodation for humans is not a priority, and most of the design features in ecological restoration projects are focused on vegetation. Some traditional ecological restoration sites do not provide any facilities that fulfill basic needs such as public restrooms, since underground pipes and connecting to the grid for seems unnecessary consider the site is rarely visited.

In the cases profiled for this study, amenities of varies types were observed (shown in Table 6.7). Thoughtfully designed furniture was common such as benches that allow gatherings of small and large groups of visitors and sculptures for ornamental and educational uses. Well-designed shading structures are also present. The shading structures not only support public use, and they make the site more user friendly under extreme weather conditions. With more financial investment, other amenities include buildings such as educational centers, public restrooms are also available. Three of the four studied sites, except for Guodu Forestry Park, have such buildings.

The number of amenities present indicates much public use of the site is encouraged. So, to determine how much public use is encouraged, the sites were characterized in the following way. The lowest degree of encouragement of public use is the provision only of essential amenities such as restrooms and parking. An intermediate level is apparent in the provision of furniture such as benches of varying sizes, colors and materials and shading structures that allow for other programed uses, lighting, and shading structures. All four study site are implemented with variety of lighting and sitting, and three of them except for Guodu Forestry Park provided shading at certain area of the park. The greatest degree is apparent in the provision of sculpture, an educational center, and other installations. It is the part where shows through the designs, the connection to people been elevated into the culture level. Where opportunity presents to express cultural relevance that is local and indigenous, which is important for place making. However, some of the latter are surprisingly unsustainable. For example, garden sculptures installed at the entrance of the Xi'an Eco Park is a sign of welcome but is also inconsistent with the goal of ecological restoration. The juxtaposition of the theme of "ecological restoration" with the presence of unsustainable features, such as these flowers, shows that ecological restoration parks are in experimental phase and are still finding a balance between fulfilling ecological goals, inviting public use, and fulfilling cultural values. Some other amenities observed include surveillance camera and share bike stations.

Table 6.7 List of Amenities

Site	Essential Supportive			Furnitures		Sign of Encouragement		Others	
	Restrooms	Parking	Lighting	Sitting	Shading Structure	Sculptures	Education/ Visitor center	Surveillance Camera	Sharebike
Chanba Wetland Park	√	√	√	√	√	√	√		√
Xi'an Eco Park	√		√	√	√	√	√	√	√
Guodu Forestry Park	√		√	√		√			
Yanming Lake Park	√	√	√	√	√	√			√

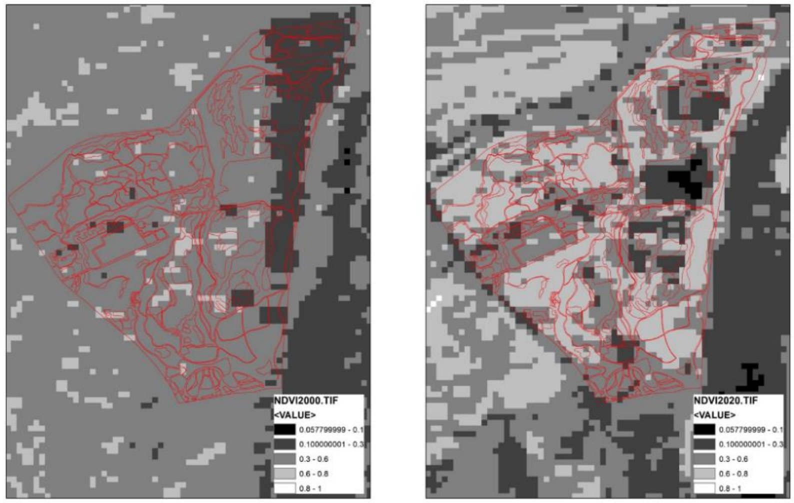
Figure 6.15 Collection of amenities at the four parks.

6.1.6 Vegetation

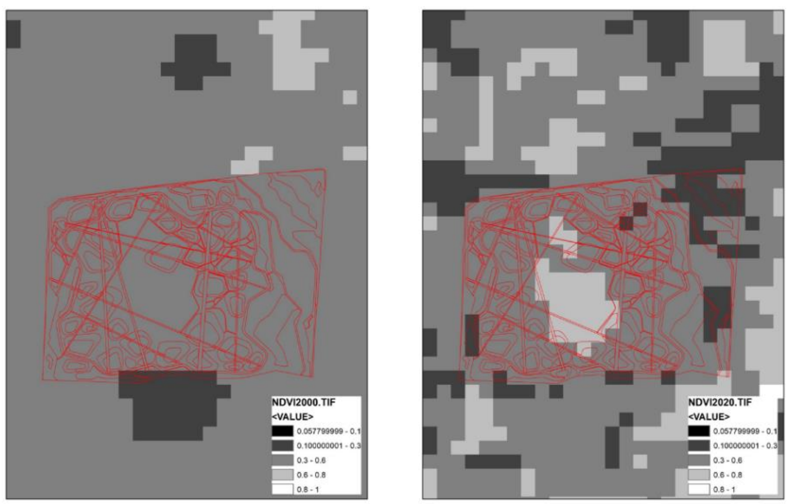
Vegetation is one of the most prominent features of ecological restoration projects since many ecological goals are closely tied to the growth and health of vegetation. Vegetated ecosystems function through the interaction among carbon, nutrients and hydrological cycles. For example, Chanba Wetland Park is designed with the goal of wetland restoration with 412 acres of wetland area, more than 22 different types of aquatic plants (Xi'an Chanba Wetland Park, 2020). Based on field observations, most of the aquatic planting area is restricted to public access. Presumably to protect due restored vegetation. Yanming Hu Park, with the specific restoration purpose of providing a habitat for migration birds, has an upland forest with multiple layers of vegetation. Vegetation with good under storage volume is helpful for birds with nesting needs. Diverse types of vegetation and providing multiple layers of vegetation are commonly considered beneficial in vegetated ecological systems. For example, even though Xi’an Eco Park, does not have an explicit restoration goal, is still planted with diverse vegetation layers of arbors, shrubs and grasses.

One other aspect of vegetation design for ecological restoration project is the selection of native vs, invasive species. Native vegetation typically is defined to include naturally occurring local vegetation, in some cases defined as vegetation that existed before a certain date(Productivity Commission, 2004, p. 10). Invasive vegetation, referring to vegetation that show a tendency to spread out of control, may post challenge on the growth of native species over more favorable growing environment. The over dominating growth of invasive vegetation sometime lead to the decline of other vegetation species, which lower the local species. Therefore, the use of native vegetation species is often used as an indicator for the ecological restoration performance. All four parks in this study shows very high percentage in native vegetation when restoring vegetation coverage. For example, in Yanming Lkae Park, of the 28 types of arbor tree surveyed, 24 of them are native tree species.

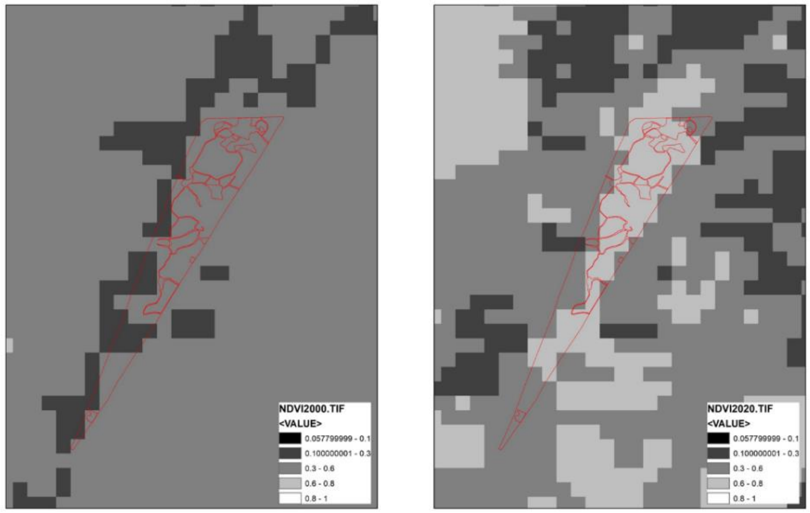
The transformation of vegetation status within the site as the result of ecological restoration effort could be quantified using the 30 meters NDVI within the four sites. Figure 6.16 shows the comparison of NDVI for four sites in 2000 and 2020. The result indicate noticeable higher productivity level in Chanba Wetland Park, Xi’an Eco Park and Guodu Forestry Park. In order to quantify the average difference in NDVI across the site. The mean difference between 2000 and 2020 is compared in Figure 6.17 using box whisker plots showing mean NDVI and standard deviations. The Histograms of the values are also plotted showing the distribution of NDVI values across each site. While comparing and processing the data, water areas are removed to make sure results reflects only the changes happens in the vegetated area. The box whisker plots verified the two trends observed in four site: Chanba Wetland Park and Guodu Forestry Park shows higher mean productivity in 2020 than 2000; while Xi’an Eco Park and Yanming Lake Park shows very similar mean value for productivity but with higher variation in NDVI. The variation which described by standard deviation of NDVI is used to estimate species richness of vegetation community (Gould, 2000). Paired T test is performed to determine the significance of the difference between 2000 and 2020 NDVI, and summarized in Table 6.8 Statistical Analysis of NDVI Comparison for Four Study Sites Between 2000 and 2020 (Water Area Removed)



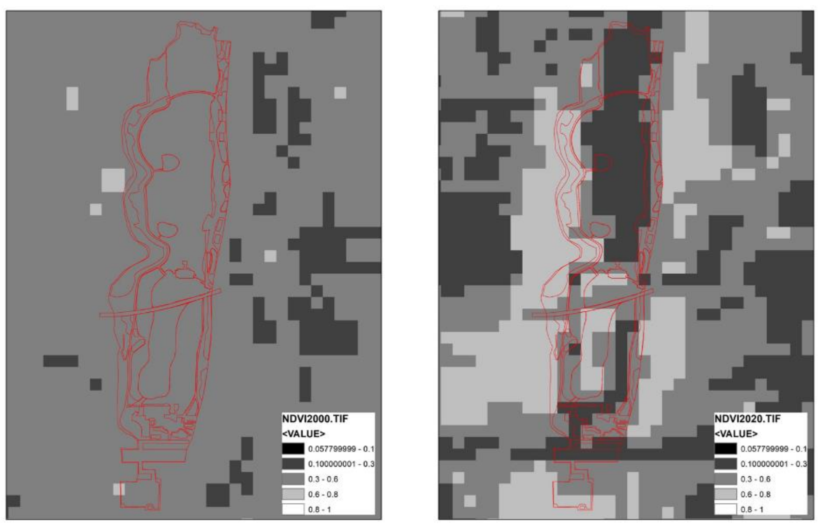
(a) 30 meters NDVI of Chanba Wetland Park (2000 vs.2020)



(b) 30 meters NDVI of Xi'an Eco Park (2000 vs.2020)

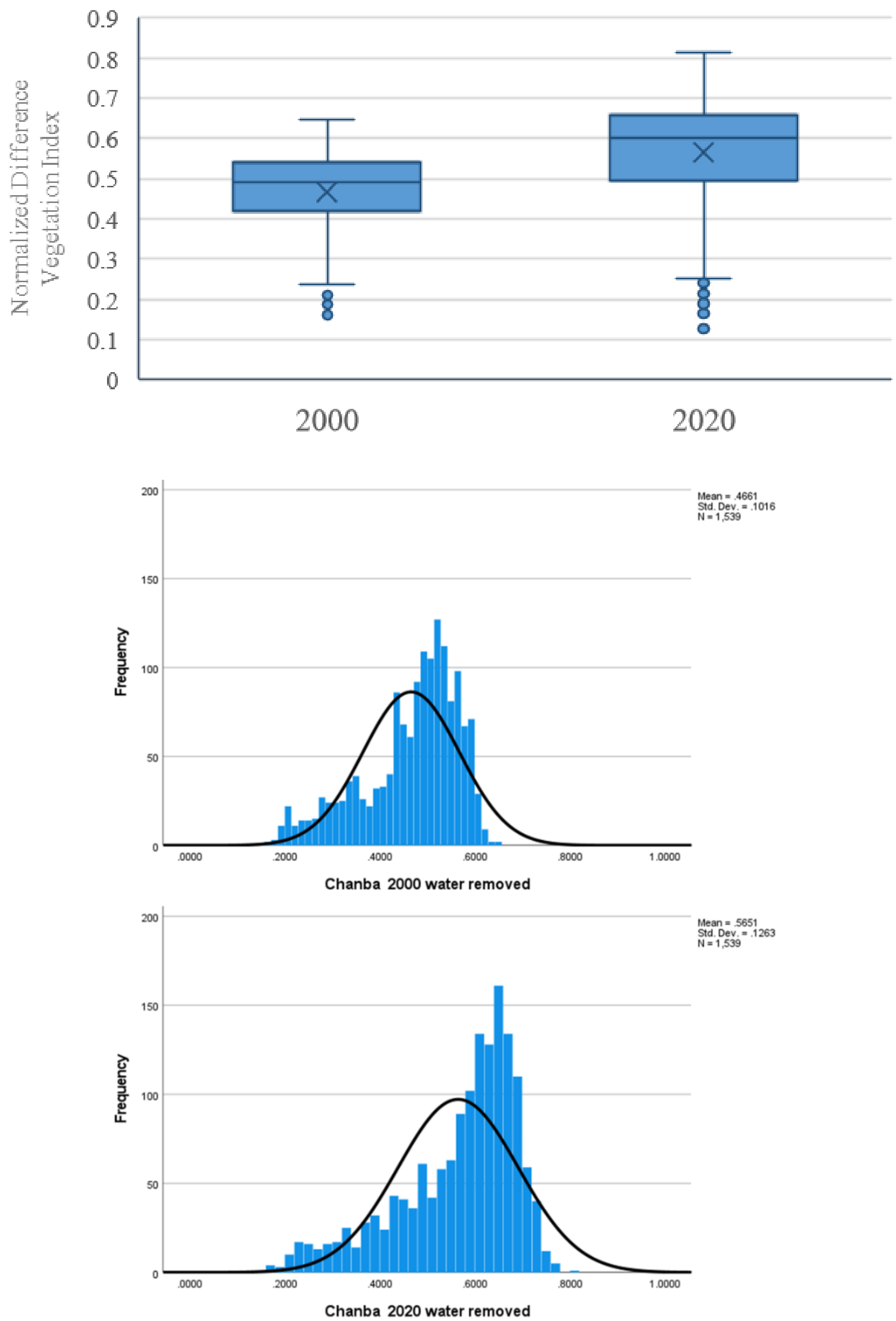


(c) 30 meters NDVI of Guodu Forestry Park (2000 vs.2020)

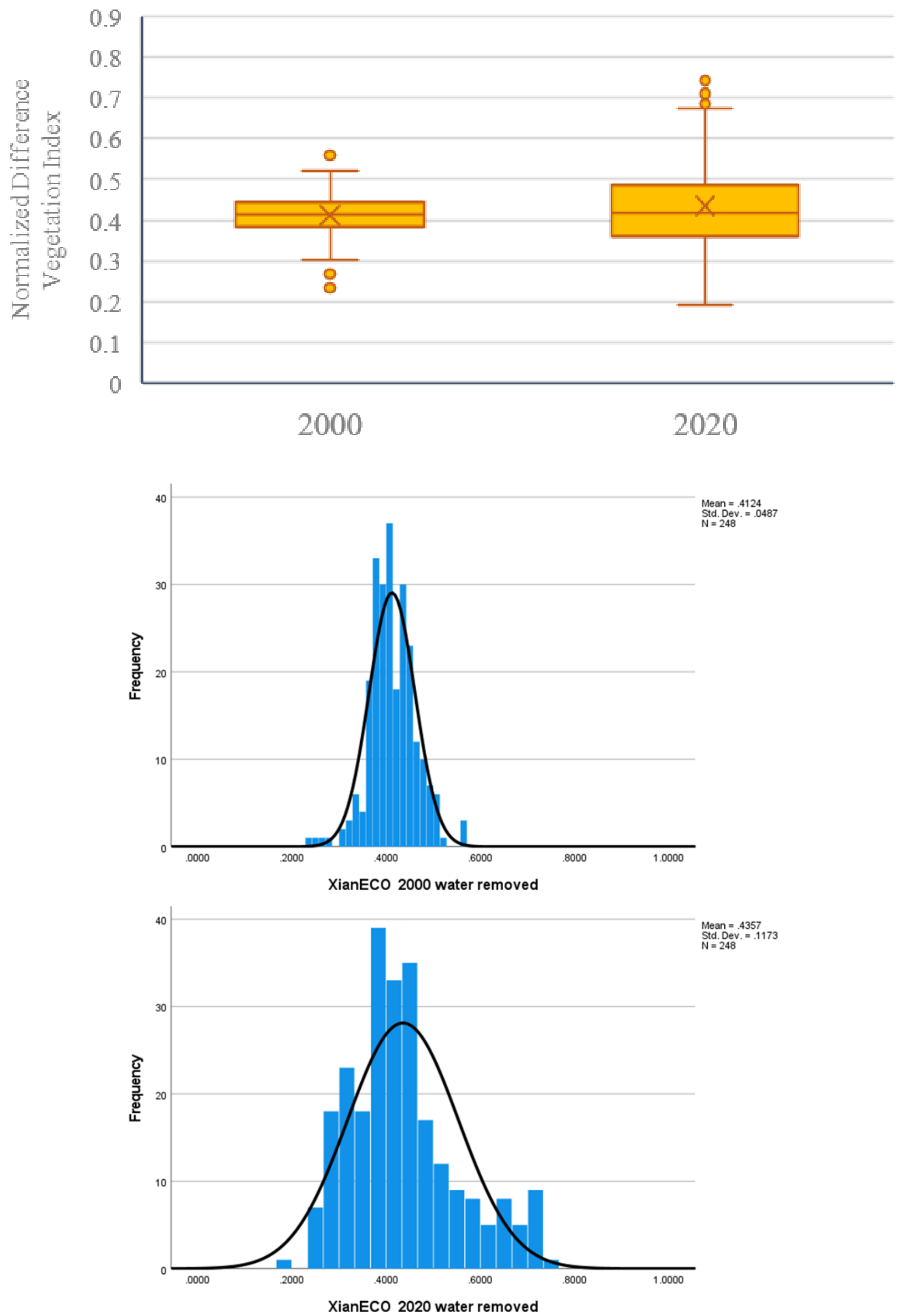


(d) 30 meters NDVI of Yanming Lake Park (2000 vs.2020)

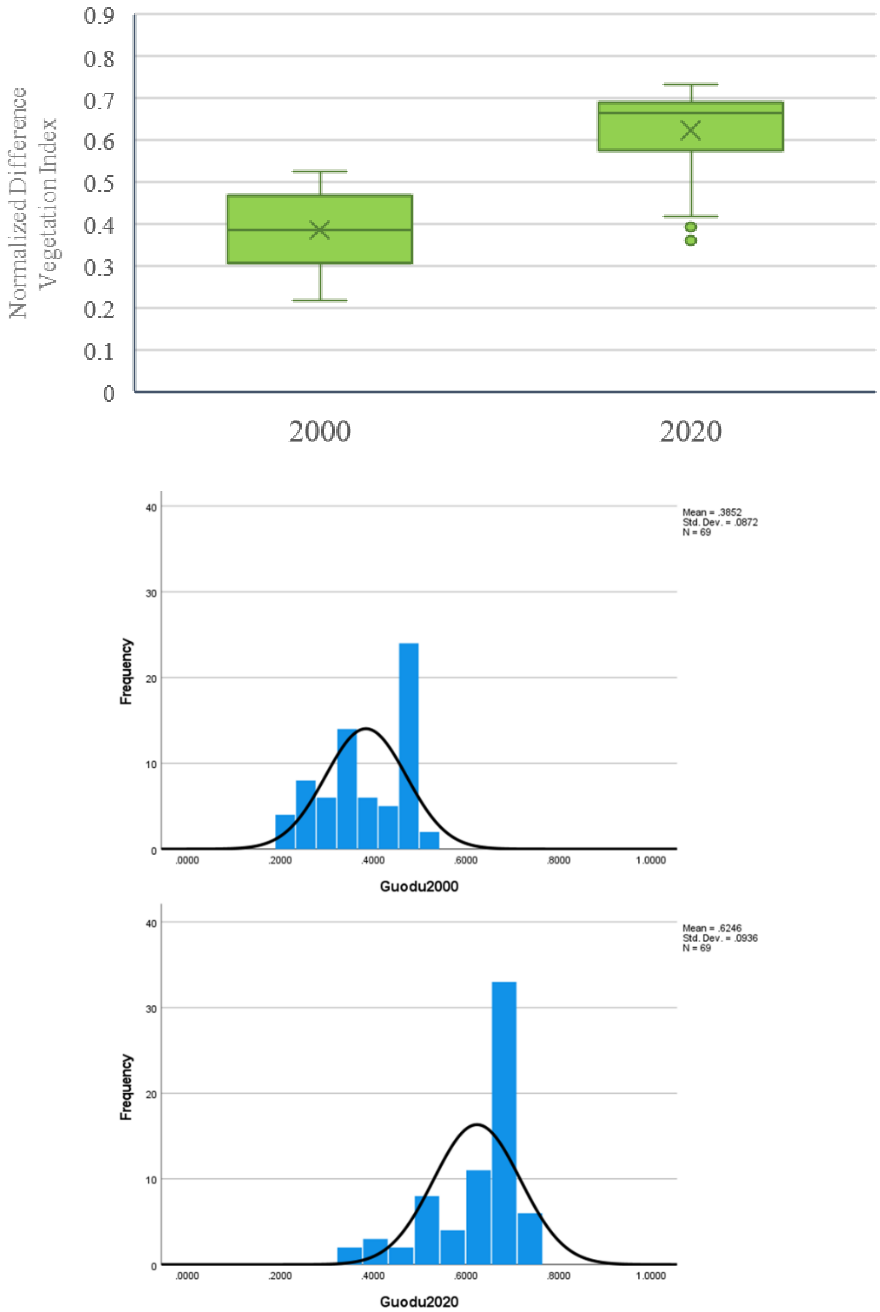
Figure 6.16 2000 vs. 2020 comparison of 30 meters NDVI of four study sites



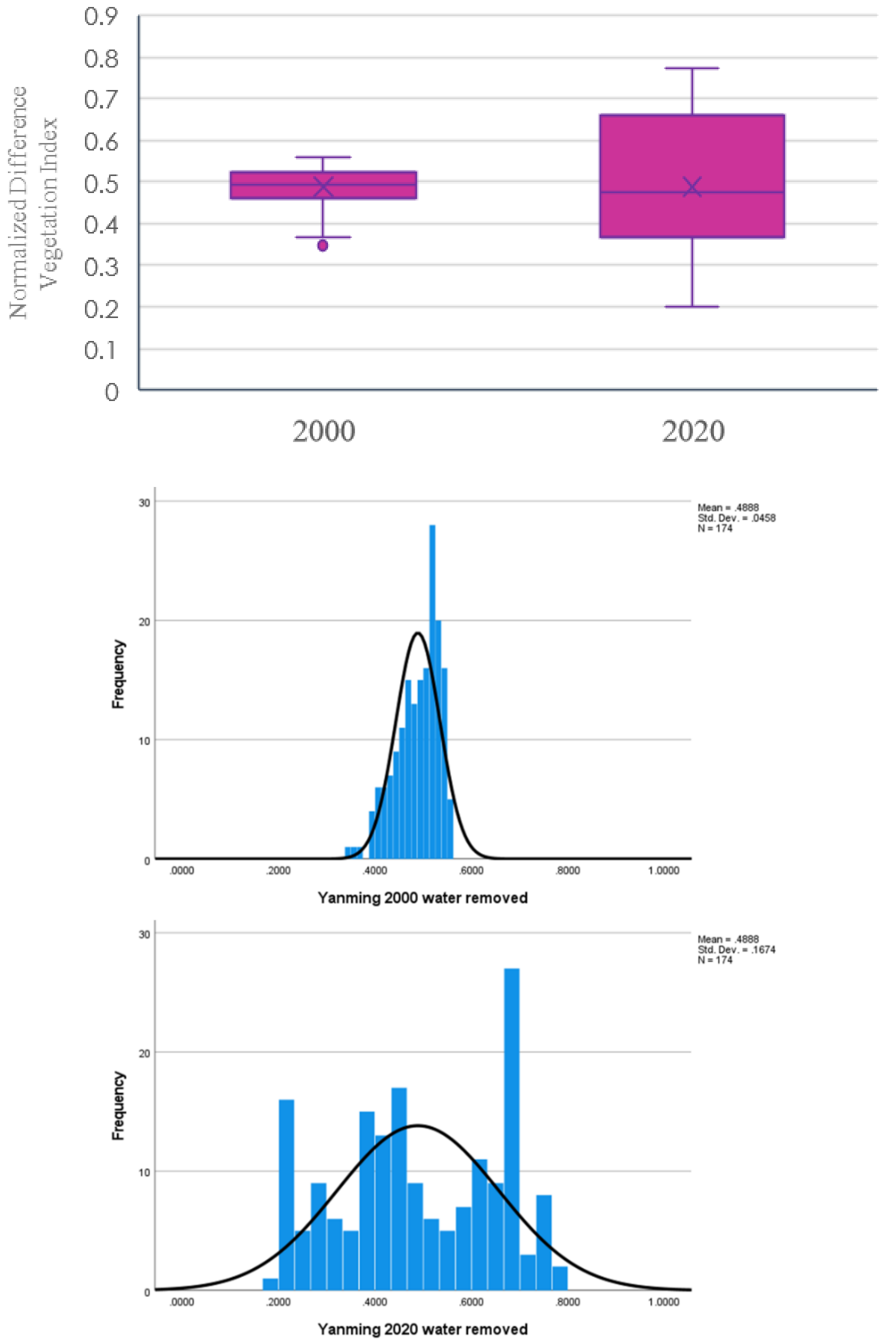
(a) Distribution of NDVI (Chanba Wetland Park 2000 vs.2020)



(b) Distribution of NDVI (Xi'an Eco Park 2000 vs.2020)



(c) Distribution of NDVI (Guodu Forestry Park 2000 vs.2020)



(d) Distribution of NDVI (Yanming Lake Park 2000 vs.2020)

Figure 6.17 Statistical distribution of NDVI between 2000 and 2020 (water removed).

Table 6.8 Statistical Analysis of NDVI Comparison for Four Study Sites Between 2000 and 2020 (Water Area Removed)

Name	Year	N	Mean	Std.Deviation	Sig. (2-tailed)
Chanba Wetland Park	2000	1539	0.466146	0.1016059	0.000*
	2020	1539	0.565059	0.1263197	
Xi'an Eco Park	2000	248	0.412379	0.0486673	0.006*
	2020	248	0.435656	0.117303	
Guodu Forestry Park	2000	69	0.385216	0.871624	0.000*
	2020	69	0.624583	0.935962	
Yanming Lake Park	2000	174	0.488828	0.0457835	1.000
	2020	174	0.488828	0.1674105	

Note: *p significant at <0.01

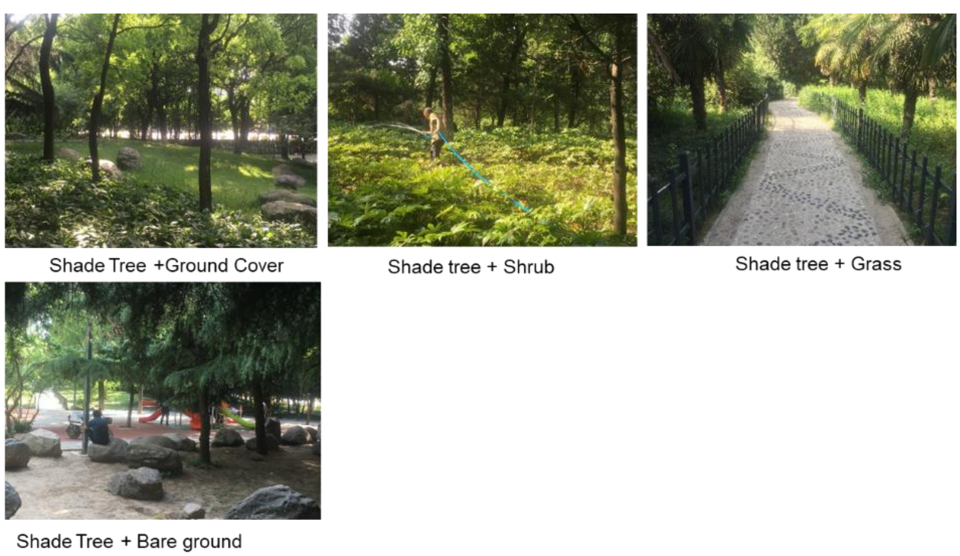
Vegetation is also a tool for educating public about the local ecosystem. Sometimes it is supplemented with signs and labels that can help build environmental literacy. In all five parks studied, vegetation are tags with the names and botanical information. At Chanba Wetland Park and Xi’an Eco Park, introduction boards are established for visitors to read detailed information about some of the plants. Urban ecological systems that are approachable by people offer opportunities for the next generation to develop a better understanding of human/nature relationships.

Planting design strategies for creating physical or visual connections between visitors and restored vegetation are common. For example, in Chanba Wetland Park, shade trees such as weeping willows and Chinese ash provide shade for visitors. Fruit trees such as peach, and apple trees are also present in the highly maintained park areas of Chanba Wetland Park, providing visitors a U-pick experience. Visitors were also observed using the fruits to feed wild ducks and geese. In these cases, the integrative experiences between people and the park are achieved through the selection of certain plant species, as well as the diversity of vegetation community structure. In most traditional public green spaces in China, very much like the western design fashion, green spaces are occupied by ornamental trees, pruned hedges, lawns and flowerbeds. As time goes by, people develop misperception towards “nature” or even as “sustainable”. However, with the problems appearing among planted vegetation, such as the biodiversity decrease and landscape homogenization. It is important to understand the difference between simply being “vegetated” and having good ecological performance.

In the previous studies on evaluating the vegetation component of ecological restoration project, many of them looked at species level, more specifically the evaluation on native vs. nonnative species. However, in urban environment, everything is rapidly changing, in terms of context and climate, boundary between native vs. nonnative becomes blurry, and due to the scale of the projects I studies, looking at species level is challenging. The alternative is to look at the vegetation structures. The structural complexity of vegetation is beneficial for facilitating biodiversity by increasing available niche space for other flora and fauna species. Therefore, to understand not only horizontal but also vertical variation in the structure of vegetation community, a documentation of the vegetation community combinations observed in each site by vertical variations is conducted, such as lawn or ground cover showing vegetation at the ground level, grass or shrubs at lower to eye level, shade tree above eye level. Figure 6.18 Summary of vegetation community structures in four study sites shows the different types of vegetation community structures in four study sites. The result shows patterns in design with intention for more complex spatial dynamic manifest by vegetation, although some of them shows following traditional garden landscape aesthetic values, and in need of maintenance to maintain such appearance.

(a) Vegetation structures observed in Chanba Wetland Park

(b) Vegetation structures observed in Xi’an Eco Park



(c) Vegetation structures observed in Guodu Forestry Park

(d) Vegetation structures observed in Yanming Lake Park

Figure 6.18 Summary of vegetation community structures in four study sites.

6.1.7 Wildlife

The primary goal of traditional ecological restoration projects is to restore either a vegetation community or a wildlife community through the reestablishment of their habitats. For example, Yanming Lake Eco Park aims to restore a habitat for geese by establishing waterways and an upland forest. Chanba Wetland Park, which serves as an important stop for migratory birds, plans to provide a habitat for more than 100 different species of such birds. The wetland and water system in that park also serves as home for more than 200 types of other terrestrial and aquatic animals(Xi'an Chanba Wetland Park, 2020). Both vegetation and the restored hydrological systems support the wildlife community. Therefore, the presence of wildlife indicates the success of the restoration by achieving a stable vegetation and hydrological status.

People are drawn to such settings in urban areas to see birds like wild goose, swans and aquatic animals like turtles. According to surveys conducted for this study, 28% of visitors think the sites studied are successful because certain wildlife species were observed onsite. Many see encounters with wildlife as educational moments for themselves and for younger generations. Providing opportunities for the public to connect with wildlife and wild vegetation helps to gain the public's interest and approval. The direct and indirect economic benefits of ecological restoration rely on the public's engagement. While many people enjoy the presence of wildlife, some experiences can be unpleasant. Vegetation that generates greater biodiversity affects human experience in some negative ways such as with its encouragement of insects. While insects are a feature of in healthy ecosystems as they help soil decomposition and provide food source wildlife species, they also pose challenges to public use. It was frequently reported in the survey conducted for this study that the great number of mosquitos is one of the least favorite experiences people have near restored wetlands. There are also safety concerns arising from people being unfamiliar animals such as wild rabbit or rats that are believed to convey diseases. Compared to urban ecological systems located in the remote area, in cities the boundary between people and wildlife can become blurred and complicated. For human users, minimally interruptive uses can be achieved with design elements such as boardwalks separate the circulation of people from animals. Providing bio-diverse supportive structure such as vegetation with eatable fruits as a food source for the animals. The safety of the human population can be ensured by selective restoration strategies such as aiming at particular wildlife species that are less aggressive. Birds are usually the idea target for urban forestry projects, while fish and turtles are good indicators of improved water quality in wetland restoration sites. Safety can also be ensured by adopting certain maintenance strategies, such as designating particular areas for wildlife nesting and restricting human access to them.

Maintenance of vegetation in these sites differs from maintenance of both traditional ecological restoration sites and traditional public spaces. In traditional public spaces furniture, lighting, roadways and walkways are maintained regularly. For parks that are heavily vegetated, the maintenance of vegetation usually follows routines similar to those of garden landscaping, where appearance is very important. In this new type of ecological restoration parks, the vegetation and its role in shaping human/ wildlife relationships makes the health of vegetation very important. To meet the objective of creating or recreating a self-sustaining ecological system, the vegetation in ecological restoration parks is usually designed and planted at a "community" scale. This means that the vegetation thrives or dies as an entire community. So, its survival depends partially on maintenance efforts and partially on the resilience of the community as a whole. Maintenance of vegetation in this case is a higher priority in ecological restoration parks as a group, comparing to the maintenance of vegetation in traditional parks which is prioritized on ornamental individually. One benefit of this community-scale planting strategy is that it requires a reduced maintenance effort (hopefully). Interviews with maintenance teams from the five cases studied confirmed that intense maintenance work is required only the early stages of developing these restoration sites when the vegetation community is still young and fragile. Vegetation at the community scale becomes more resilient once the entire community is mature and natural succession takes over. To fulfill the sites' restoration goals, the cases observed in this study, with the exception of Guodu Forestry Park have designated areas with no physical access by the public. Visual access is made possible through elevated pathways like bridges and boardwalks.

Management features such as hours of operation, rules and regulations are additional features of ecological restoration parks. Similar as regular parks, some ecological restoration parks adopt hours of operation out of maintenance or safety concerns. Hours of operation vary between sites. For example, some sites are open daily at certain hours, while others are only partially open or only on certain days of the week or month. In other cases, the entire site is closed to the public for certain periods of time in the year. The latter is very common when the restoration goal is to restore a certain wildlife community. Then the restriction of human access is usually for their special needs, for example, breeding. For example, Chanba Wetland Park has an entire conservation area with no public access for protection of endangered wildlife species such as Chinese Merganser, while the rest of site is open to the public from 9 am to 6 pm. Guodu Forestry Park, Xi'an Eco Park and Yanming Hu Park are open 24 hours a day to the public. When websites fail to provide sufficient information on how and when the public can visit can confuse potential visitors and reduce the number of visits.

Another important management practice is the posting of rules and regulations at the site that list prohibited activities, such as smoking and feeding animals. A common practice for enforcing rules and regulations is the employment of on-site security guards. Two of the sites in this study (Chanba Wetland Park and Xi'an Eco Park) have on-site uniformed guards cruising through the site. Interviews with the security guards revealed that their primary responsibility is to monitor behavior for criminal activities or minor violations such as riding motorcycles, bringing domestic animals to the site, and littering.

Programming of events is another indicator of the park's encouragement of public use. In Chanba Wetland Park, Xi'an Eco Park and Yanming Hu Park, even though the sites are geared toward ecological restoration, playgrounds and exercise equipment are provided. Programmed events are also made possible with collaborations between government entities, developers, maintenance teams, and local institutions and are supported through digital media. For example, an ecological themed Flash Mob was organized by the city government with participation by local dance schools at Chanba Wetland Park on March 8 2019. The activity took place at the large gathering platform near the entrance of the park. Such programed activities are aimed at increasing public stewardship of this public park by providing ecological knowledge in entertaining ways.

Even though the economic value of urban ecological system is becoming more evident and well recognized, the means for raising revenue to protect these ecological amenities for public access often is unstable. The financial means for initiating the project as well as for covering maintenance costs are very important for the success of this type of project. The diversity of funding sources is one of factors that needs to be considered for the long term sustainability of the project. This study identifies four categories of funding sources for this type of public space in China: the state budget, local loans, self-raised funds through developers and foreign investment. Among them, state budget and self-raised funds have consistently increased from 2009 to 2015 as reported by the China National Bureau of Statistics(Yearbooks China Statistical, 2015), Funds from other funding sources have been less consistent.

6.2 Users and Uses

The public's responses to the four parks studied were collected through on-site surveys and interviews and through reviews of on-line sources of information. In the onsite survey, the user diversity was measured by demographic characteristics including gender, age, occupation, and home ownership. A total of 79 questionnaires were collected. The occupations of the respondents varied, office employed (10%), sales (15%), migrant/construction work (5%), unemployed (23%), construction work (13%), tech (5%), business owner (5%), retired factory work (4%), student (13%), retired teacher (8%). Sixty three percent of the participants are homeowners, 37% are renters.

Table 6.9 summarizes the participants answers to questions including: home's approximate to the site, term of residency, means of transportation, and their impression on whether the site qualify as ecological restoration. Above 85% of the visitors who responded to the survey are returning visitors. Around 65% agree that the environment at the site has been greatly improved through the restoration efforts. More than 56% of visitors spend more than two hours per visit in the park. Participants were asked whether they consider the park they were visiting to be an ecological restoration project. Most responded with "don't know". Only a few (13%) said "Yes". People who responded "yes" were further asked “Why?”. The answers referred almost exclusively to the fact that the site is vegetated. The result shows even though people enjoy the use of this new type of public space, in general they lack an understanding urban ecological system. Since the survey is only conducted for people age above 18, the percentage of young visitors are not clear. However, the elderly and children are observed to be the major user groups of all these parks.

Table 6.9 Summary of Response in User Survey

	Chanba (A)		Xi'an Eco Park (B)		Guadu Forestry (C)		Yanming Lake (D)		Total	
	N	%	N	%	N	%	N	%	N	%
Total	15	100%	20	100%	14	100%	30	100%	79	100%
Occupation										
Office employed	3	20%	2	10%	2	14%	1	3%	8	10%
Sales	2	13%	4	20%	3	21%	3	10%	12	15%
Migrant worker	0	0%	2	10%	2	14%	0	0%	4	5%
Unemployed	2	13%	5	25%	2	14%	9	30%	18	23%
Construction worker	0	0%	1	5%	3	21%	6	20%	10	13%
Tech	2	13%	2	10%	0	0%	0	0%	4	5%
Business owner	0	0%	0	0%	1	7%	3	10%	4	5%
Retired factory worker	1	7%	0	0%	0	0%	2	7%	3	4%
Student	3	20%	4	20%	0	0%	3	10%	10	13%
Retired teacher	2	13%	0	0%	1	7%	3	10%	6	8%
Gender										
F	8	53%	8	40%	9	64%	9	30%	34	43%
M	7	47%	12	60%	5	36%	21	70%	45	57%
Home Ownership										
Home Owner	8	53%	12	60%	9	64%	21	70%	50	63%
Home Renter	7	47%	8	40%	5	36%	9	30%	29	37%
How far do you live from the site?										
Less than 1km	0	0%	4	20%	7	50%	3	10%	14	18%
1km to 2km	2	13%	12	60%	5	36%	6	20%	25	32%
More than 5km	13	87%	4	20%	2	14%	21	70%	40	51%
How long have you lived around here for?										
Do not permantly live locally	0	0%	2	10%	0	0%	0	0%	2	3%
Less than 1 year	3	20%	4	20%	1	7%	6	20%	14	18%
1 to 5 years	4	27%	14	70%	4	29%	3	10%	25	32%
5 to 10 years	2	13%	0	0%	7	50%	12	40%	21	27%
more than 10 years	6	40%	0	0%	2	14%	9	30%	17	22%
What's your means of transportation today?										
Bus	4	27%	6	30%	3	21%	9	30%	22	28%
Subway	0	0%	0	0%	0	0%	0	0%	0	0%
Drive	7	47%	4	20%	0	0%	6	20%	17	22%
Taxi	2	13%	0	0%	0	0%	0	0%	2	3%
Bike	2	13%	2	10%	4	29%	3	10%	11	14%
Walk	0	0%	8	40%	7	50%	12	40%	27	34%
Do you think this park qualify as Ecological Restoration?										
Yes	13	87%	6	30%	5	36%	9	30%	33	42%
No	0	0%	6	30%	4	29%	0	0%	10	13%
NA	2	13%	8	40%	5	36%	21	70%	36	46%

The findings from the observation are summarized in Table 6.10. Both the visitor's group size and activities are documented to investigate the use of each site as public space. The result shows more people travels in group of more than 3 in Chanba Wetland Park, while in the other three parks, people are less observed to be in groups.

Table 6.10 Summary of Observations of Users

			No. of People			Activities									
Name	Site No.	Total (N)	1	2	>3	Sitting	Standing	Passingby	Exercise	Talking	Reading	Using Electronic	Eating	Dancing	Smoking
Chanba Wetland Park	A	130	7.7%	38.5%	53.8%	23.1%	34.6%	26.9%	7.7%	34.6%	0.0%	3.8%	7.7%	3.8%	0.0%
Xi'an Eco Park	B	323	32.1%	38.1%	28.8%	14.4%	48.8%	30.7%	5.6%	5.1%	0.0%	4.7%	0.9%	0.0%	0.5%
Guodu Forestry Park	C	75	46.7%	36.7%	16.7%	26.7%	10.0%	30.0%	13.3%	20.0%	0.0%	10.0%	3.3%	0.0%	0.0%
Yanming Lake Park	D	348	49.1%	33.6%	17.2%	3.4%	10.6%	76.4%	7.8%	19.0%	0.0%	7.8%	0.3%	4.6%	1.4%

Varieties of wheels are observed showing people’s mean of travel in public spaces has becoming more diverse. Without motor vehicle, people visiting the parks do not only reply on foot, the use of other types of wheels challenges the design and maintenance of surfaces in the park. Bikes, scooter, skateboard, wheelchairs, and strollers all travel at different speed and yet are circulated together with pedestrian, which is also potentially unsafe for the pedestrian experience.

Figure 6.19 Visitors travels in different types of wheels.

Observations of uses also revealed that spaces are well used when the spaces are large invite particular kinds of uses (Figure 6.20). The programed open spaces such as lawn, playground areas, exercise areas are popular among visitors. The large gathering spaces take the foot traffic load off from the ecological "zone" of the park, where foot traffic is mostly diverted into small gathering spaces or circulation only (Figure 6.21).

Figure 6.20 People clusters where large open spaces are provided.

Figure 6.21 Diverted circulation into the more protected area.

For the purpose of understanding the public's opinion of site features and general design, a large number of review comments (1005 comments from four review websites) were studied. Initial findings reveal positive responses towards structures such as public restrooms and parking spaces. The most frequent terms associated with higher ratings is "convenience", "getting physical exercise" and "spending time with children". Table 6.11 Summary of *Social Media Reviews* of the Study Sitespresents the result from detailed content analysis of social media reviews of the study sites and it helps to understand public's use and perception regarding ecological systems in this context. The results show that "plant diversity" is mentioned more in visitors' comments comparing to the mentioning of other features such as "water", "tree", "wild life" or "flower". "Ease of access" is also mentioned very frequently, this includes people's comments on how easy or how difficult the site is to reach. Finding also reveal strong opinions towards structures such as public restrooms and parking spaces when there is issue associated.

Both on-site surveys and interviews with users indicate that the public response in general is very positive towards the sites studied. The social media reviews became part of my collected data to supplement user survey interrupted due to COVID 19, however the amount of information retrieved from this source is surprisingly extensive. Across industries, social media is becoming an essential strategy to gather people's opinions. Comparing to pre- structured survey, the comments from social media are voluntarily and open- ended. Sometimes the comments offer answers to questions that researchers didn't know to ask. And it helped researchers to get more extended understanding toward public's view to this type of public space. For example, the complains towards the selection of native grasses, "why does the park has so much weed and why are the park does not have much paved area, it does not look like a park" it also aligns with the finding of the survey in terms of lack of understanding towards urban ecological system. and shows the importance of this subject matter.

Table 6.11 Summary of Social Media Reviews of the Study Sites

			Features of Interest												
Name	Site No.	Total (N)	Water	Flower	Tree	Plant Diversity	Lawn	Wild Life	Overall Env.	Easy Access	Lighting	Shading	Onsite Vendor	Public Transpor
Chanba Wetland Park	A	201	9.0%	6.0%	9.0%	11.9%	3.0%	41.8%	20.9%	16.4%	0.0%	10%	10%	6%
Xi'an Eco Park	B	459	0.0%	15.7%	11.8%	15.0%	32.7%	0.0%	11.1%	27.5%	3.3%	1%	4%	8%
Guodu Forestry Park	C	45	0.0%	0.0%	13.3%	33.3%	0.0%	0.0%	0.0%	26.7%	33.3%	0%	20%	0%
Yanming Lake Park	D	300	22.0%	10.0%	9.0%	6.0%	5.0%	26.0%	27.0%	13.0%	2.0%	0%	6%	6%

~ Table Continues ~

~ Table Continued ~

Features of Interest				Activities				Special Comments			
Public Restro	Kid Play	Furniture	Resturant Nearby	Exercise	Picnic	Fishing	Biking	Easy Parking	Issue with Parking	Insects Related	Other
4%	4%	1%	0%	0.0%	3.0%	0.0%	0.0%	22.4%	4.5%	4.5%	13.4%
12%	27%	7%	1%	10.5%	7.2%	0.0%	3.9%	0.7%	20.3%	2.6%	3.9%
0%	0%	7%	0%	6.7%	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	6.7%
4%	14%	3%	3%	23.0%	7.0%	11.0%	1.0%	13.0%	3.0%	2.0%	6.0%

CHAPTER 7

IMPLICATIONS

Four cases of ecological restoration parks in Xi'an, China are described in this dissertation. All of them exemplify a new type of public space, one that is intended and designed to support local vegetation and wildlife, both of which require particular management and maintenance practices. They also differ from traditional ecological restoration sites in that they allow and even encourage public access and public use.

The four cases also exemplify four different approaches to ecological restoration. Chanba Wetland Park consists of large wetland restoration areas some of which are open to the public and some are not for habitat protection. Yanming Lake Park has medium sized wetland restoration areas that are completely open to the public. Guodu Forestry Park consists of medium sized areas of forestry restoration that are completely open to the public. And Xi'an Eco Park has large areas of grassland and shrubland restoration that are completely open to public.

The findings of this research suggest that the methods that have been used in the past to evaluate traditional public spaces and traditional ecological restoration sites are not sufficient for evaluating this new type of hybrid social/ecological space. More specifically, drawing from the ecological sciences is not sufficient for understanding the human/ nature relationship in urban restoration projects. Contributions from the disciplines of social science and the humanities could help identify reasonable goals for understanding and evaluating restoration projects in today's complex social context. Also, studies are needed that address both the social and the ecological performance of ecological parks in urban areas and their impact on the social, economic, and ecological environments in which they are imbedded. One of the key challenges of ecological restoration sites in general is the following of maintenance in a sustainable way. Without proper management (self or external) the project will not survive to a long healthy trajectory after initiation. It is not uncommon that the places eventually be overgrown with weeds and filled with wastes. Restoration or re-construction of ecological system in urban area is not simply aesthetical landscape design, it is a much more complex task that involve the consideration of future operation and maintenance. The practice calls for innovative opportunities for programing in order to provide financial support for the long-term operation. Therefore, in order to discover the long-term ecological and financial sustainability of such initiatives, more studies are needed to compare the management maintenance practices of this type of project.

The value of ecological restoration in urban environments extends beyond the eco-services they provide to include the ecological education they could also provide. Constructed ecological systems in urban areas, such as ecological restoration parks, when properly maintained and well accessed by the public, can serve as the perfect means for providing an ecological education that future generations need. This is important for creating comprehensive environmental literacy, which eventually can lead to collaborative actions among decision makers, developers, and designers for solving many environmental problems in urban areas.

While this dissertation focused on the restoration of the park itself and the surrounding area, ecological restoration could also be pursued at a regional and even a national scale. As illustrated in Figure 7-1, the top-down approach that underlie the planning practice observed in this dissertation research focus on the ecological re-construction of medium to large ecological systems. Projects following the top-down approach are also implemented at a faster pace than projects following the bottom-up approach and relies on funding from the government, a practice that is vulnerable since the government might allocate funds elsewhere due to policy changes. The challenge therefore is to create opportunities for self-sustaining modes of operation, as listed under the bottom-up approach shown in Figure 7.1. By doing that, the government would be able to release funds to support additional projects of this type and eventually create sustainable urban ecological systems that connect the parks with each other.

The western practices that follow a "bottom-up ecological planning" approach, which is mostly community driven and designed more to meet local needs than the needs of the larger eco-system, has it benefits in strengthening public stewardship of the land. In these circumstances however, public access becomes challenging, for example due to a lack of funding for maintaining the necessary features that support public use.

A new, third approach should be explored for the long-term success of ecological restoration with consideration of the larger ecological context. This new approach would include planning at both national and regional levels with sufficient government support but also with public participation in planning and design at the neighborhood level. In adopting these two planning strategies, public access to the park is maintained, and the park remain self-sustaining should the government funding no longer being available. Local community participation ensures a connection with local cultural and historical values while also protecting the ecological value of the parks.

Top-down ecological reconstruction	**Bottom-up ecological planning**
Planning by national government without public participation	Public participation in planning
Designed for eco-tourists	Designed for local users
Funding from the government	Funding from both private and government sources

Figure 7.1 Two approaches of ecological restoration.

In this day and age, public spaces can be multi-dimensional, flexible containers for a variety of uses in the changing dynamics of urban environments. Introducing public access to ecological restoration areas represents an evolution from a previously one-dimensional understanding of ecological systems to a multidimensional recognition of them as social as well as ecological systems. Ecological restoration areas such as parks are a perfect example. They demonstrate the beginning of a flexible urban infrastructure that can accommodate future yet unknown conditions in the complex urban systems we have built. This new type of park is still young and still in an experimental phase in the densely populated urban centers in China. During the research about the four cases, it became clear that these ecological restoration parks are designed as living labs for testing out new ideas of sustainable infrastructure, industrial design, and, most importantly, for creating a balance between the needs of humans and nature through the design and maintenance of vegetation. There are more possibilities down the road such as connecting an ecological park with the local urban agricultural system. It is also important to explore opportunities for expressing cultural relevance that is local and indigenous which are important for place making.

To conclude, I will re-characterize urban ecological restoration as: The effort to restore or re-construct ecosystem functions to improve their health, integrity, and sustainability in urban areas while also acknowledging their social and cultural complexity. Sustainable landscape planning that seeks to strengthen the conservation of biodiversity of natural resources is still in an experimental phase. Most of the projects implemented under this concept are recently constructed. Future longitudinal research is needed to determine the long-term performance of such initiatives.

APPENDIX A

VISITOR QUESTIONNAIRE

This is a research project about the Ecological Restoration and Urban Repair Program and the design of urban parks. Please circle your answer (answers) or write them down in the provided space provided.

1. Are you aware of the Ecological Restoration Program?

   Yes / No

2. What do you know about this program?

   ____

   ____

3. How far away do you live from this park?
   a. Within 1 mile
   b. One mile to 5 miles
   c. More than 5 miles
4. How long have you been living in this area?
   a. Less than 1 year
   b. 1 year to 5 years
   c. More than 5 years
   d. More than 10 years
5. What type of transportation do you use to get to this park?
   a. Bus b. Subway c. Private Car d. Taxi e. Bike f. Walk

6. What is the purpose of your visit to the park today?

____

____

7. Did you visit the park before (explain project)?

   Yes / No

8. (If yes), How did the project change the park, how much of an improvement do you think it is after the site being redesigned?

   It greatly improved the park

   It improved the park somewhat

   It improved the park a little

   It did not improve the park at all

9. Why do you feel that way?

10. What do you like about the park?

____

____

11. What do you not like about the park?

____

____

12. Do you think this park is a successful implantation of the Ecological Restoration and Urban Repair Program,

    Yes/ no

    Why do you feel that way?

____

____

13. Is there anything else you want to tell me about the Ecological Restoration and Urban Repair Program?

____

____

14. How often do you visit this park

    More than once per week

    More than once a month

    Less than once per month

15. How much do you spent in this park during each visit

    a.Less than 1 hour b. 1-2 hours c. more than 2 hours

16. What kind of physical actives do you do on site

    Walking/ Running/Dancing/Reading/Exercising Equipment /Other_________

17. Do you visit the park alone or with other people?

    Alone

    With a few friends/family

    With a group

18. How kind of actives do you engage in with other people in the park?

____

19. Have you ever interacted with new people in the park, if yes, how?

____

20. How stressful do you feel in your daily life?

Not at all

A little stressful

Average

Very

Extremely

21. How relaxed do you feel after visiting of this park?

Yes/No

22. Is there anything else you want to talk about this park?

____

____

____

23. Age: ________ Gender: _________ Occupation: ___________

APPENDIX B

GUIDELINES FOR INTERVIEW WITH PUBLIC USERS

Thank you for agreeing to participate in my dissertation research. This interview will take about 10 to 15 minutes and will be recorded. You will only be asked about information relevant to this site (state the name of the site). It is my responsibility to inform you that your participation is anonymous and voluntarily based, you may refuse to answer any question or end the interview at any point.

General Questions

1. How long have been living in the city?
2. How often do you come to the park?

About Ecological Restoration and Urban Repair Program

1. How does the Ecological Restoration and Urban Repair program affect your life?

About the Site

1. Have you been to this site before the park was built?
2. What was it like?
3. How do you think about the design of this park?
4. What is your favorite thing about this park?
5. What is your least favorite thing about this park?
6. How do you think this park changed the neighborhood environment?
7. Is there anything else you want to share with me about the park?

APPENDIX C

CHECKLIST FOR USER OBSERVATION

Checklist for User Observation

Site:	Date:	Date of Week:	Weather:
Observer:	Start Time:	End Time:	Observation#:
Type of Access：			
Note:			

Activity Checklist

Number of people			Activities										
One	Two	Three or more	Sitting	Standing	Walking	Exercising	Chatting	Reading	Electronic devices	Eating	Dancing	Smoking	Other(Note)

APPENDIX D

SITE FEATURE DOCUMENTATION CHART

Documentation of Site Features

Site:	Date:	Date of Week:	Weather:
Observer:	Observation#:	Note:	

Site Features Documentation

Wildlife	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:
	No.	Type:	Species:	Number:	Photo #:

Note:

Documentation of Site Features

Site:	Date:	Date of Week:	Weather:
Observer:	Observation#:	Note:	

Site Features Documentation

Vegetation	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #:
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #
	No.	Vegetation Name:	Vegetation type:	Number or area size:	Photo #

Note:

Documentation of Site Features

Site:	Date:	Date of Week:	Weather:
Observer:	Observation#:	Note:	

Site Features Documentation

Vertical	No.	Intended use:	Description:	Photo #:
structures	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
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	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
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	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:
	No.	Intended use:	Description:	Photo #:

Note:

REFERENCES

Akbari, H. (2002). Shade trees reduce building energy use and CO^2 emissions from power plants. Environmental Pollution, 116, S119-S126.

Altieri, M. A., Companioni, N., Cañizares, K., Murphy, C., Rosset, P., Bourque, M., & Nicholls, C. I. (1999). The greening of the "barrios": Urban agriculture for food security in Cuba. Agriculture and Human Values, 16(2), 131-140.

Amadeo, K. (2018). China's economy facts and effect on the U.S. economy. Retrieved from https://www.thebalance.com/china-economy-facts-effect-on-us-economy-3306345. Retrieved on 5 December 2019

Andersson, E. B., S. Ahrn,xe,K. (2007). Measuring social-ecological dynamics behind the generation of ecosystem services. Ecological Applications, 17(5), 1267-1278.

Best management practices for lead at outdoor shooting Ranges. (2005). (Environmental Protection Agency -902-B-01-001). https://www.epa.gov/lead/best-management-practices-lead-outdoor-shooting-ranges.

Bird, W. (2007). Viewpoint--Natural GreenSpace. Br J Gen Pract, 57(534), 69.

Blair, R. B., & Launer, A. E. (1997). Butterfly diversity and human land use: Species assemblages along an urban grandient. Biological Conservation, 80(1), 113-125.

Byrne, J., Wolch, J., & Zhang, J. (2009). Planning for environmental justice in an urban national park. Journal of Environmental Planning and Management, 52(3), 365-392.

Brander, L. M., & Koetse, M. J. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. Journal of Environmental Management, 92(10), 2763-2773.

Burls, A. (2007). People and green spaces: Promoting public health and mental well-being through ecotherapy. Journal of Public Mental Health, 6(3), 24-39. doi: 10.1108/17465729200700018

Cao, S. (2011). Impact of China's large-scale ecological restoration program on the environment and society in Arid and Semiarid Areas of China: Achievements, Problems, Synthesis, and Applications (Vol. 41).

Cendrowski, S. (April 28, 2014). Business created China's pollution problem - now it needs to fix it. Fortune. Retrieved from http://fortune.com/2014/04/10/business-created-chinas-pollution-problem-now-it-needs-to-fix-it. Retrieved on 8 December 2018.

Chang, C. Y., Yu, H. Y., Chen, J. J., Li, F. B., Zhang, H. H., & Liu, C. P. (2014). Accumulation of heavy metals in leaf vegetables from agricultural soils and associated potential health risks in the Pearl River Delta, South China. Environmental Monitoring and Assessment, 186(3), 1547-1560. doi:10.1007/s10661-013-3472-0

Chaparro, L., & Terradas, J. (2009). Ecological services of urban forest in Barcelona. Institut Municipal de Parcs i Jardins Ajuntament de Barcelona, Àrea de Medi Ambient.

Chen, Y. (2006). Assessing the services and value of green spaces in urban ecosystem: A case of Guangzhou City. Hongkong University Theses Online (HKUTO). Hongkong, China

Checker, M. (2011). Wiped out by the "greenwave": Environmental gentrification and the paradoxical politics of urban sustainability. City & Society, 23(2), 210-229.

China's Forestry Yearbook. (1997). Beijing China's Forestry Publishing House.

China yearbook of statistics. (2004). Beijing, China: Statistics Press.

Chinese statistical year book. (2004). Chinese Statistical Press.

Ding, C. (2003). Land policy reform in China: assessment and prospects. Land use policy, 20(2), 109-120.

Elmqvist, T., Setälä, H., Handel, S. N., van der Ploeg, S., Aronson, J., Blignaut, J. N., de Groot, R. (2015). Benefits of restoring ecosystem services in urban areas. [Review Article]. Current Opinion in Environmental Sustainability, 14, 101-108. doi: 10.1016/j.cosust.2015.05.001.

Escobedo, F. J., Kroeger, T., & Wagner, J. E. (2011). Urban forests and pollution mitigation: analyzing ecosystem services and disservices. Environmental Pollution (Barking, Essex: 1987), 159(8-9), 2078-2087. doi: 10.1016/j.envpol.2011.01.010.

Escobedo, F. J., & Nowak, D. J. (2009). Spatial heterogeneity and air pollution removal by an urban forest. [Article]. Landscape and Urban Planning, 90, 102-110. doi: 10.1016/j.landurbplan.2008.10.021.

Escobedo, F. J., Wagner, J. E., Nowak, D. J., De la Maza, C. L., Rodriguez, M., & Crane, D. E. (2008). Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forests to improve air quality. Journal of Environmental Management, 86(1), 148-157.

Etim, E. (2012). Phytoremediation and its mechanisms: a review. International Journal of Environment and Bioenergy, 2(3), 120-136.

Fang, J., Piao, S., Field, C. B., Pan, Y., Guo, Q., Zhou, L.,Tao, S. (2003). Increasing net primary production in China from 1982 to 1999(6), 293.

Fuller, R. A., Irvine, K. N., Devine-Wright, P., Warren, P. H., & Gaston, K. J. (2007). Psychological benefits of greenspace increase with biodiversity. Biology Letters, 3(4), 390-394.

Gill, S. E., Handley, J. F., Ennos, A. R., & Pauleit, S. (2007). Adapting cities for climate change: The Role of the Green Infrastructure(1), 115.

Gould, W. (2000). Remote sensing of vegetation, plant species richness, and regional biodiversity hotspots. Ecological Applications, 10(6), 1861-1870.

GreenCarCongress. (17 September 2007). China launches “Green Traffic Week” and “No Car Day” in 108 cities. Retrieved from http://www.greencarcongress.com/2007/09/china-launches-.html. Retrieved on 8 December 2018.

Handel, S. N., Saito, O., & Takeuchi, K. (2013). Restoration ecology in an urbanizing world Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities (pp. 665-698): Springer.

Hobbs, R. J., Arico, S., Aronson, J., Baron, J. S., Bridgewater, P., Cramer, V. A., Lugo, A. E. (2006). Novel ecosystems: theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography, 15(1), 1-7.

Hu, Y. Z., Yue. (2016-11-17). Ecological restoration big part of guideline, China Daily. Retrieved from http://www.chinadaily.com.cn/china/2016-11/17/content_27400764.htm, Retrieved on 24 September 2019.

Huang, S., Liao, Q., Hua, M., Wu, X., Bi, K., Yan, C., . . . Zhang, X. (2007). Survey of heavy metal pollution and assessment of agricultural soil in Yangzhong district, Jiangsu Province, China. Chemosphere, 67(11), 2148-2155.

Huijun, G., Aiguo, C., Yongneng, F., Padoch, C., & Coffey, K. (2002). Economic development, land use and biodiversity change in the tropical mountains of Xishuangbanna, Yunnan, Southwest China. Environmental Science and Policy, 5(6), 471-479. doi:10.1016/s1462-9011(02)00093-x.

Jim, C. Y., & Chen, W. Y. (2009). Ecosystem services and valuation of urban forests in China. Cities, 26(4), 187-194.

Johnson, I. (2013). China' s great uprooting: moving 250 million into cities. The New York Times. Retrieved from https://www.nytimes.com/2013/06/16/world/asia/chinas-great-uprooting-moving-250-million-into-cities.html Retrieved on 8 September 2019

Joss, S. (2010). Eco-cities: a global survey 2009. The Sustainable City VI: Urban Regeneration and Sustainability, WIT Press, Southampton, 239-250.

Joss, S. (2011). Eco-cities: The mainstreaming of urban sustainability–key characteristics and driving factors. International Journal of Sustainable Development and Planning, 6(3), 268-285.

Kaye, J. P., Groffman, P. M., Grimm, N. B., Baker, L. A., & Pouyat, R. V. (2006). A distinct urban biogeochemistry? Trends In Ecology & Evolution, 21(4), 192-199.

Kocs, E. A. (2013). Finding nature in the city: A case study of ecological restoration in an urban park: City University of New York.

Laituri, M. (1996). Cross-cultural dynamics in the ecocity: Waitakere City, New Zealand. Cities, 13(5), 329-337.

Lin, D. H., Li, X. M., Wang, B., Hong, Y., Fang, X. Y., Qin, X. O., & Stanton, B. (2011). Discrimination, perceived social inequity, and mental health among rural-to-urban migrants in China.

Lin, P. (2017). 以点带面促转型—住房城乡建设部全面部署开展"城市双修"工作 (From points to area- Ministry of Housing and Urban-Rural Development plans for ecological restoration). Retrieved from http://www.mohurd.gov.cn/zxydt/201704/t20170424_231585.html. Retrieved on 03 August 2018

Low, S. M. (2001). The edge and the center: gated communities and the discourse of urban fear. American Anthropologist, 103(1), 45-58.

Larson, C. (2009, April 6). China's grand plans for Eco-cities now lie abandoned. Yale Environment 360.

Macedo, J. (2004). Curitiba. Cities, 21(6), 537-549.

Mega, V. (2000). Cities inventing the civilisation of sustainability: an odyssey in the urban archipelago of the European Union. Cities, 17(3), 227-236.

Netease News. (July 25, 2012). "Beijing officials have yet to release latest flood casualt data".Retrieved from http://news.163.com/12/0725/21/879QGHTA0001124J.html

Nowak, D. J. (2007). Assessing urban forest effects and values : New York City's urban forest: United States. Forest Service. Northern Research, Station.

Pataki, D. E., Carreiro, M. M., Cherrier, J., Grulke, N. E., Jennings, V., Pincetl, S., . . . Zipperer, W. C. (2011). Coupling biogeochemical cycles in urban environments: ecosystem services, green solutions, and misconceptions. Frontiers in Ecology and the Environment, 9(1), 27-36.

Perrow, M. R., & Davy, A. J. (2002). Handbook of ecological restoration (Vol. 2). New York City, New York. Cambridge University Press.

Perry, E. (2008). Great wall across the Yangtze. In PBS (Producer).

Pinto, A. P., de Varennes, A., Fonseca, R., & Teixeira, D. M. (2015). Phytoremediation of Soils Contaminated with Heavy Metals: Techniques and Strategies. In A. A. Ansari, S. S. Gill, R. Gill, G. R. Lanza & L. Newman (Eds.), Phytoremediation: Management of Environmental Contaminants, Volume 1 (pp. 133-155). Cham: Springer International Publishing.

Qiang, M. (2009). Eco-city and eco-planning in China: taking an example for Caofeidian eco-city. Paper presented at the Proceedings of the 4th International Conference of the International Forum on Urbanism.

Qiu, X. (2015). 20 世纪 50 年代初内蒙古自治区的植树造林事业(Reforestation efforts in Inner Moglia in the 1950s). Youth Wenxuejia Journal Publisher (4X), 191.

Productivity Commission. (2004). Impacts of native vegetation and biodiversity regulations.

Rapoport, E. (2014). Utopian visions and real estate dreams: The Eco-city past, present and future. Geography Compass, 8(2), 137-149. doi:10.1111/gec3.12113.

Afforestation on Stemps (1958). China Philatelic Information. Retrieved on 12 May 2019.

Ren, H., & Peng, S. (2003). The practice of ecological restoration in China: A Brief History and Conference Report. Ecological Restoration(2), 122.

Remaud, G. (2016). Numbers tell the story at Liberty State Park | Opinion. New Jersey Opinion, March. Retrieved from http://www.nj.com/opinion/index.ssf/2016/03/numbers_tell_the_story_at_liberty_state_park_opini.html. Retrieved on 19 July 2019.

Rose-Wilen, E. (2017). Accessible strategies for community influence on open space policy and planning: A New Jersey case study. George H. Cook Scholars Thesis, New Brunswick: Rutgers University.

Schmidt, M. W., Torn, M. S., Abiven, S., Dittmar, T., Guggenberger, G., Janssens, I. A., Manning, D. A. (2011). Persistence of soil organic matter as an ecosystem property. Nature, 478(7367), 49-56.

Shao, M., Tang, X., Zhang, Y., & Li, W. (2006). City clusters in China: air and surface water pollution. Frontiers in Ecology and the Environment, 4(7), 353-361. doi:10.1890/1540-9295(2006)004[0353:CCICAA]2.0.CO;2

State Environmental Protection Administration. (1995-2004). Beijing, China: Environmental Science Press.

Sugiyama, T., Leslie, E., Giles-Corti, B., & Owen, N. (2008). Associations of neighbourhood greenness with physical and mental health: do walking, social coherence and local social interaction explain the relationships? Journal of Epidemiology & Community Health, 62(5), e9-e9.

Suttmeier, R. P. (2012). China's management of environmental crises: risks, recreancy, and response. In Chung, Jae Ho, ed. China's crisis management. London; New York: Routledge, 2012. xiv, 151p. (China policy series, 20) (pp. 108-129).

Takano, T., Nakamura, K., & Watanabe, M. (2002). Urban residential environments and senior citizens' longevity in megacity areas: the importance of walkable green spaces. [Research Support, Non-U.S. Gov't]. J Epidemiol Community Health, 56(12), 913-918.

Tan, S, & Zhao, W. (2007). Social and psychological benefit of urban green space. Journal-Chongqing Jianzhu University, 29(5), 6.

Troy, A., Morgan Grove, J., & O'Neil-Dunne, J. (2012). The relationship between tree canopy and crime rates across an urban–rural gradient in the greater Baltimore region. Landscape and Urban Planning, 106(3), 262-270. doi: https://doi.org/10.1016/j.landurbplan.2012.03.010

Upton, J. (2013, Jul 25). China to spend big to clean up its air. Grist. Retrieved from http://grist.org/news/china-to-spend-big-to-clean-up-its-air. Retrieved on 8 July 2018

Valli, R. (April 25, 2014). China revises environmental law. Voanews. Retrieved from https://www.voanews.com/a/china-revises-environmental-law-to-address-pollution-problems/1900981.html. Retrieved on 16 July 2019

Van Renterghem, T. H., Maarten; Forssen, Jens; Botteldooren, Dick. (2013). The potential of building envelope greening to achieve quietness. Building and Environment, 61, 34-44.

Wang, A. (2007). Environmental protection in China: the role of law. Chinadialogue. Retrieved from https://www.chinadialogue.net/article/show/single/en/745-Environmental-protection-in-China-the-role-of-law

Wang, Y., & Murie, A. (1999). Housing policy and practice in China: Macmillan.

Williams, A. (2017). China's Urban Revolution: Understanding Chinese Eco-Cities: Bloomsbury Publishing.

Wong, N. H. T., Alex Yong Kwang; Tan, Puay Yok; Chiang, Kelly; Wong, Ngian Chung. (2010). Acoustics evaluation of vertical greenery systems for building walls. Building and Environment, 45(2), 411-420.

Wortley, L., Hero, J.-M., & Howes, M. (2013). Evaluating ecological restoration success: A review of the literature. Restoration Ecology, 21(5), 537-543. doi:https://doi.org/10.1111/rec.12028.

Xi'an Chanba Wetland Park. (2020). Park Introduction Retrieved from http://www.chanbawetland.com/about/gongyuanjianjie. Retrieved on 8 July 2020

Xinhuanet. (2009). 1973 年：环境保护开始起步（Enviornmental protection taken off）. Retrieved from http://www.gov.cn/jrzg/2009-08/30/content_1404821.htm.

Yang, C., & Wu, C. (1996). 中国土地使用制度改革十年 (Ten-year reform of land use system in China). Zhong Guo Da Di Publisher, Beijing, China.

Yearbooks China Statistical. (2015). National data, National Bureau of Statistics of China. Retrieved from http://www.stats.gov.cn/tjsj/ndsj/2015/indexeh.htm

Zhang, C., & Chai, Y. (2014). Un-gated and integrated Work Unit communities in post-socialist urban China: A case study from Beijing. Habitat International, 43, 79-89.

Zhang, P., Shao, G., Zhao, G., Master, D. C. L., Parker, G. R., Dunning Jr, J. B., & Li, Q. (2000). China's forest policy for the 21st century. Science(5474), 2135.

Zhang, P., Zhou, X., & Wang, F. (1999). Introduction to natural forest conservation program. China's Forestry Publishing House, Beijing, 388.

Zhao, S., Da, L., Tang, Z., Fang, H., Song, K., & Fang, J. (2006). Ecological consequences of rapid urban expansion: Shanghai, China. Frontiers in Ecology and the Environment, 4(7), 341-346.

Zheng, Z., Gao, J., Ma, Z., Wang, Z., Yang, X., Luo, X., . . . Fu, G. (2016). Urban flooding in China: Main causes and policy recommendations. Hydrological Processes, 30(7), 1149-1152. doi:10.1002/hyp.10717

Zhu, X. (1956). 炼钢炉前. Selected Art Works by Zhu Xuanxian. Shanghai People's Fine Arts Publishing House, Shanghai.

People's Daily Online. (August 6, 2012). "79 People Killed in the Flood". Retrieved from https://web.archive.org/web/20121109121351/http://xj.people.com.cn/n/2012/0806/c186332-17325550.html. Retrieved on 16 November 2018.

Ministry of Housing and Urban-Rural Development of the People's Republic of China (MOHURD). (2016). Ecological Restoration and Urban Repair to Promote Urban Transformation. Retrieved from http://www.mohurd.gov.cn/jsbfld/201612/t20161212_229812.html.