# The Knowledge and Attitude to Species Invasion Issue in Greenway Planning: A Study in China

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## Introduction

Greenway is important green infrastructure which has ecological, recreational and cultural/historic functions applied in macro(country), medium(region) and micro(city) levels. Generally, greenway is in linear or reticular forms so that it is called "way". Greenway has a long history in United States and Europe, and many successful projects have been implemented. Conversely, greenway has a very short history in China, because China lately started it urbanization in 1990s with a low degree of urbanization, which had grown from 26.37% in 1991 to 36.22% to 2000. Thus, for a long time, Chinese landscape architects had focuses on the level of urban area and lower ones, rather than higher levels of region and nation. The first paper on greenway in China published on a journal of urban planning, introducing greenway movement in United States [1]. Unfortunately, this paper had not drawn enough attention of landscape architects, because of the disciplinary separation of landscape architecture and urban planning in China. There had been no paper on greenway for 10 years since then.

In the new century, greenway starts to be paid attention. In 2001, it was first time when paper on greenway was published in a journal of landscape architecture in China, which introduced the development of greenway in United States [2]. After it, the number of papers on greenway increases. Two groups of papers selected from the 2rd Fobos International Conference on Greenway and Landscape Planning 2010 were published as special topic on the Journal of Chinese Landscape Architecture and the Journal of Landscape Architecture, China, which introduced greenway development and projects in United States and European countries to Chinese professionals, and evoked wide repercussions. Two books on greenway, *Greenways: A Guide To Planning Design And Development* by Charles Flink (Author), Robert Searns (Author), Loring LaB. Schwarz (Editor) and *Ecological Networks And Greenways: Concept, Design, Implementation* by Rob H. G. Jongman and Gloria Pungetti (Editor) was published in China in 2009 and 2011, and became "must read" books for greenway planners. As the result of rapid urbanization, a growth from 36% to 50% during the first decade of new century, and rethinking of urban-rural integration, greenway projects starts in China. Though Zhejiang government first made its provincial greenway planning in 2004, Guangdong is the first province who started greenway implementation in 2010. Guangdong plans to build 8770 km province-level greenway by 2015, and it had finished 2372 km province-level greenway and 4978 km city-level greenway by the end of 2012. Stimulated by Guangdong, other provinces or metropolises have started their ambitious plans of greenways, as rapid and colossal as their urbanization plans (Table 1). Moreover, during the project of Supplying Water from South China to North, and the project of historic preservation of the Grant Canal for World Heritage application, national greenways are surmised to be built along the canals and pipelines. Now, greenway planning projects have been a new growth point of landscape architecture industry.

**Table 1.** Some greenway plans in China

| Province or Metropolis | Year to Start | Year to End | Total Length |
|---|---|---|---|
| Beijing | 2012 | 2020 | 1000 kilometers |
| Hebei | 2011 | 2013 | More than 660 kilometers |
| Anhui | 2012 | 2016 | 3000 kilometers |
| Zhejiang | 2012 | 2020 | 4000 kilometers |
| Guangdong | 2010 | 2015 | 8770 kilometers |
| Fujian | 2012 | 2020 | 3100 kilometers |
| Hunan | 2012 | 2015 | More than 3000 kilometers |

Though many landscape architecture firms and contractors benefit from the prosperity of greenway, as well as the users, the speed of greenway movement is worrying. The procedure of decision making is hasty. Many decision makers don't know what the definition of greenway is, how it functions, whether they need it, but they decide to build it because other provinces or cities have greenway plans. Some even believe greenway is just another name for trial or parkway. The hasty decision also causes irrational plans characterized by oversized scale, fast period, and repeated duplication, which leave insufficient time to study, plan, and implement. Moreover, the greenway planners don't have enough experience and knowledge so that they underestimate the potential hazards. Therefore, under such a situation, fast and large greenway plans might lead to grave consequences.

**Literal review**

Greenway is linear or reticular structured green land system. Olmstead is considered as the founder of the greenway movement. His Boston Emerald Necklace project was the first greenway, though the rudiment of greenway can be traced back to earlier boulevards in Europe. In its development, greenway has many different definitions in different countries under different cultural context. Ahern gave a widely accepted definition [3].

Greenway has similar spatial pattern to ecological network, but the original intentions were different. The former addressed human being, while the latter emphasized species and habitats, but the two concepts have been merging gradually, and now describe the green infrastructure where species communities (including human being) survive and move [4]. The conceptual merging results in some functions of corridor, component of ecological network, implemented in greenways.

Fábos divided greenways into three major categories: ecological greenways, recreational greenways and greenways with historical/cultural values [5]. Other important functions of greenways are catalyst to tourism, stimulus to economy, and preparation for urbanization, which are more concern in China, so that greenway is considered as a key approach to urban-rural integration. In addition, the traditional culture of recreation and landscape makes Chinese greenways pay more attention to the usage of human being.

Because of the merging of the concepts of greenway and ecological network, greenway borrows ideas of corridor from ecological network. Ecological corridors has important effects on ecology to protect biodiversity [6-8], but it could be the route of exotic species invasion [9], which promotes

predators and competing species spreading, speeding invasion into communities [10], especially along rivers and roads [11-13]. Bio-invasion may cause biodiversity loss [14], and even the crash of local ecological system and the changes of landscape [15].

Urbanization and globalization exacerbates exotic species invasion [16-17]. Urbanization aggravates habitat fragmentation, so that wildlife has to invade other patches to survive. Linkage of transportation network, like channels and roads, provides pathway of invasion and makes the activities easier than those in natural processes. Urbanization also results in direct human caused invasion. For example, plenty of exotic species are introduced as landscape plants, and some exclusive species, like *Rhus typhina Nut*, are changing landscape patterns of urban and rural areas, and expanding to natural areas. Globalization makes exotic species invasion across a long distance range possible, as line-haul increases [18]. Invasive species overgrow without competitors and predators, squeezes spaces of local species, and cause ecological disasters to local ecological systems. The European rabbits in Australia, Chinese mitten crabs in German, ragweed in China, and Asian carps in United States are typical cases. In most cases, the invasive species spread over corridors along roads, rivers and railways, and the damages are more severe than before.

Therefore, as spatial corridors linking urban, rural and natural areas, larger greenways with more branches and higher connectivity are getting more dangerous. Invasive species spread long greenways, from urban areas to rural and natural areas.

The exotic species invasion is not a popular issue in greenway research, and there are a few papers and publications in China mention the potential invasion in greenway. Jongman [7] cited Noss′ finding on the negative impact of greenway [9], Ahern discussed the potential possibility that connectivity causes species invasion [19], Flink and Searns pointed out the potential hazards of species invasion along corridors and suggested to make a plan in greenway planning to eliminate invasive species [20], and Fu and Luo analyzed the possibility that species invade along corridors in green land systems [21].

## Goal and objective

After analyzing some greenway planning projects in China, the researchers found that most of them over-emphasized the spatially linear pattern and connectivity, but didn′t consider the species invasion problem, and even used exotic plants. It shows that greenway planners have not enough ecological knowledge, especially on exotic species invasion, and this affects their attitudes in greenway planning. The purpose of the present study was to find out **whether** and **how** well potential species invasion is considered in greenway planning by landscape architects, **what** attitude they hold toward species invasion, and **what** results in these.

The basic hypothesis for the present study was that landscape architects, which work on greenway planning projects in China, haven′t enough knowledge on potential species invasion in greenways, thus, they paid less attention to it during greenway planning. This hypothesis was based on review of greenway papers and greenway projects, and communication with some greenway planners. The main objectives with the study were 1) to prove the hypothesis by a survey which aimed to answer the questions: **whether** and **how** well potential species invasion is considered in greenway planning, and **what** attitude is held by landscape architects; and 2) to find out **what** reason cause the result by an investigation including interviews and discussions. The questions in survey are divided into two categories: 1) the basic knowledge of species

invasion, and 2) the consideration of species invasion in greenway planning (Table 2). In addition, in order to find out the reasons to ignore species invasion, another two categories of questions are prepared for the survey: 1) the background of surveyed landscape architects, and 2) the basic knowledge of greenways (Table 3).

**Table 2.** Questions on species invasion issues

| basic knowledge of species invasion | consideration of species invasion in greenway planning |
|---|---|
| *do you know greenways will cause species invasion* | *will you consider ecological issues if you do a greenway planning* |
| *what do you think is the main invasive type* | *will you suggest the clients hire ecologists for greenway planning* |
| *is species invasion a severe problem* | *have you seen ecological feasibility reports for your greenway projects* |
| *which methods can prevent invasion (multiple choice)* | *have any ecologists joined in your projects* |
| *do you think the probability of invasion is high in greenways* | *will you consider species invasion in greenway planning* |
| | *will you consider preventive approaches if your greenway have potential invasion* |
| | *will you suggest your clients cancel it, if your greenway planning project is potential to be invaded and the invasion is hard to be solved* |

**Table 3**. General questions

| background of surveyed landscape architects | basic knowledge of greenways |
|---|---|
| what is your educational background | do you think greenways will have a successful prospect in China |
| what is your working experience | do you think greenways will improve city images |
| do you know greenways | Are you more interested in greenway projects than other landscape architecture project |
| do you have or having any greenway project | what are the main services proposed in your greenway projects |
| | what are the types of your greenway projects (multiple choice) |

## Methodology

The research strategy is based on qualitative and quantitative research methodology. The former is used to confirm **when**, **how** and **what** attitude is considered to species invasion in greenway planning, in order to prove the hypothesis presented above; the latter is used to discuss the results of quantitative research, and then demonstrate **what** reasons cause the results. The study was carried out in different stages. First, communications were established between the researchers

and professionals who are interested in the issue. In these communications, the purpose of the study was presented and the categories of questions were discussed. Secondly, questionnaires including four categories of questions were sent to more than 100 landscape architects of 18 design firms all over China. The third stage involved an analysis of the answer from the questionnaires. The results were preliminarily discussed for the stage of interviews. In the fourth stage, interviews were carried out with landscape architects selected from the survey. Finally, the researchers summed up the discussions and answers in interviews, and then gave suggestions. The interviewees were selected after the results of questionnaires, in order to make the selection representative. The 14 interviewees from different firms are of different educational background, in different positions, have different understanding of species invasion, and different attitudes to species invasion in greenway planning.

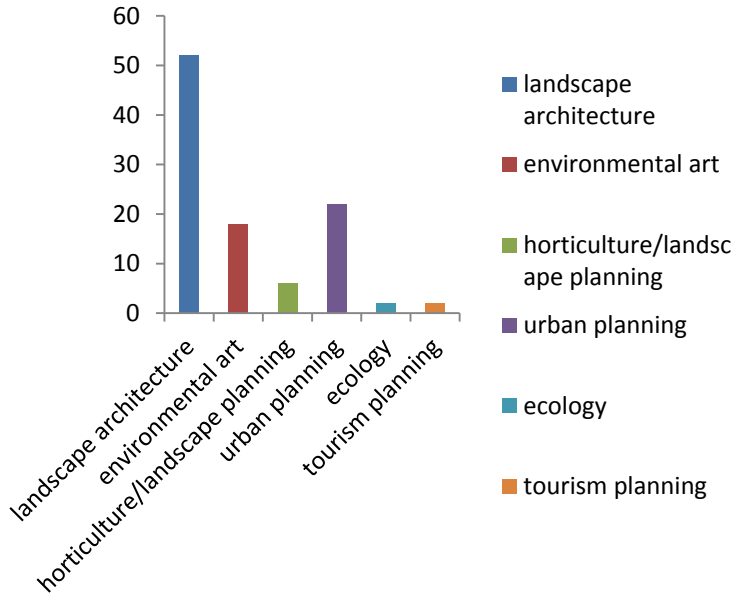
**Results**

The results presented below are based on data from questionnaires. The questionnaires were sent to 18 landscape design firms all over China, and 112 landscape architects answered and returned questionnaires. The researchers accepted 102 questionnaires as valid ones giving an 89% validity rate, because other respondents didn't know greenways. The researchers supposed that respondents without greenway knowledge cannot give precise answers.

17 of the 21 firms were doing or had done greenway planning, and the projects spread across China. This shows that greenway has been a main type of landscape architecture projects.

The respondents had various educational backgrounds, including landscape architecture, urban planning, environmental art* and other majors (Fig. 1.). 52 of them had landscape architecture degrees, about 51% of the total. Two respondents with ecology background show a gratifying progress that ecological graduates join in landscape architecture as the profession more concerns ecological issues.

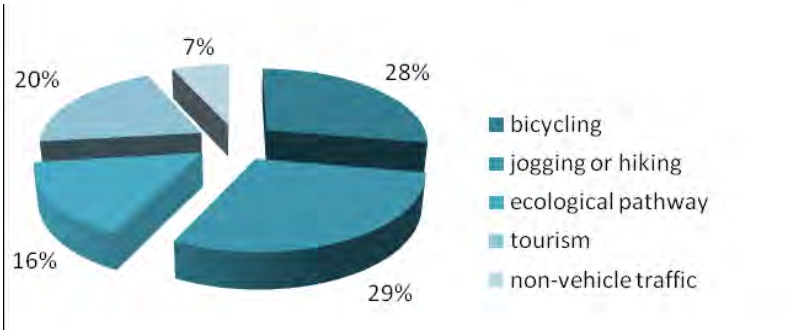
**Fig. 1.** Educational background of respondents



The majority of the respondents had a positive impression to greenways. 88.2% respondents believed that greenways would have a successful prospect in China, and 98% thought greenways would improve city images. 85.3% respondents showed that they had more or equal interests in greenway projects than other landscape architecture projects.

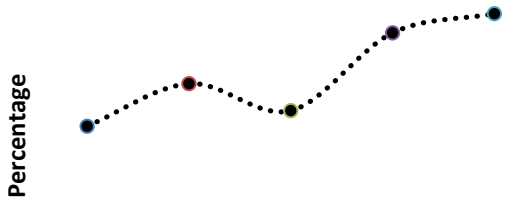
67 respondents did or were doing greenway projects, and the main services (multiple choice) proposed in the projects are for jogging or hiking (29%), bicycling (28%), tourism (20%), ecological pathway (16%) and non-vehicle traffic (7%) (Fig. 2). It shows that the key functions of Chinese greenways are recreational.

**Fig. 2.** Main services proposed in greenway projects




The category of basic knowledge of species invasion is a main part of the questionnaires. To the question "do you know greenways might cause species invasion", 54 respondents answered "yes" while other 48 said "no". It proves that landscape architects pay little attention to this problem. To their educational background, 28 of 52 landscape architecture background, 12 of 22 urban planning, 12 of 18 environmental art and 2 of 6 horticulture/landscape planting respondents answered "yes". The percentage doesn't show a correlation between the knowledge and educational background. It is incredible that the only 2 ecological background respondents answered "no", and it needs to be concerned even though it might be an individual case. 66.7% respondents who had working experience more than 10 years answered "yes", followed by experience of 5-10 years (62.5%), 1-3 years (51.4%), 3-5years (45.5%) and less than 1 year (42%) (Fig. 3). It can be deduced that greenway planners will learn more on species invasion as they work longer.

**Fig. 3.** Respondents knowing species invasion in greenway analyzed with working experience



To the question “what do you think is the main invasive type”, 14 chose “not sure”, 2 chose “animals”, 22 chose “plants”, 5 chose “microbes”, 12 chose “animals and plants”, 1 chose “animals and microbes”, 3 chose “plants and microbes” and others chose “all the three”(Fig. 4). To the question “is species invasion a severe problem”, 74.5% respondents answered “yes”, 18.6% answered “no”, and 6.9% answered “not sure”. However, to answer the question “do you think the probability of invasion is high in greenways”, 41 chose “yes”, 24 chose “no”, 37 chose “not sure”. To the question “which methods can prevent invasion (multiple choice)”, the answers from high percentages to low were “to consult ecologists” (44.7%), “to monitor in real time” (19.9%), “to set hence in greenways” (16.8%), “to introduce the predators of the invasive species” (9.3%), “to decrease the connectivity of greenways” (6.8%), and “to increase the density of plants” (2.5%) (Fig. 5).

**Fig. 4.** Main invasion types

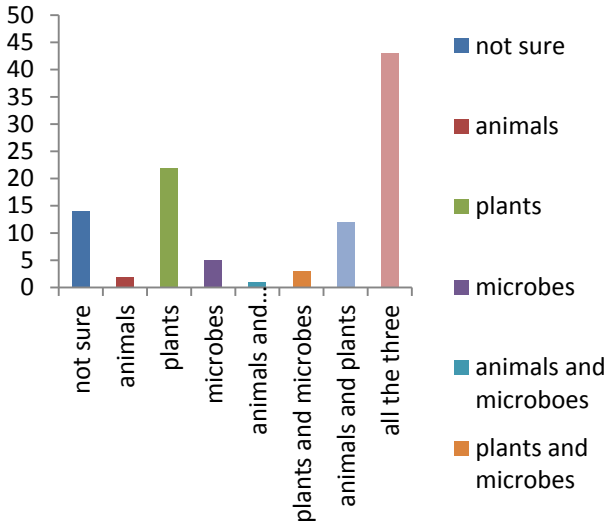
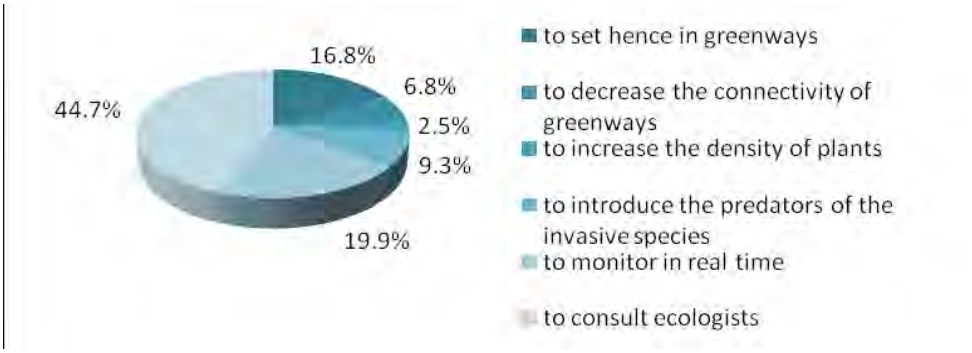


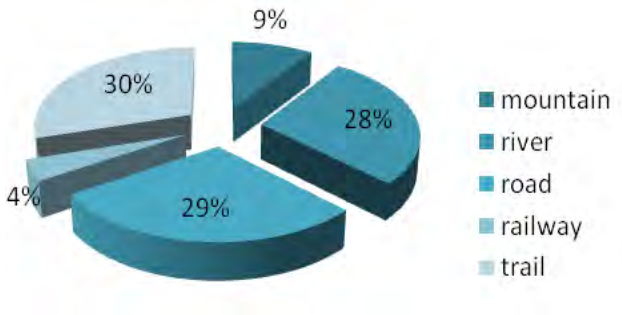

**Fig. 5.** Methods to prevent species invasion




The category consideration of species invasion in greenway planning is another main part of questionnaires. To the question “will you consider ecological issues when you do a greenway planning”, 83.3% of the 102 respondents answered “yes”, and 4.9% answered “no”, and 11.8% answered “not sure”. The high percentage of positive answers showed that greenway planners concerned ecological issues in planning. However, among the 67 respondents who had greenway planning experience, only 18 answered “yes” to the question “have you seen ecological

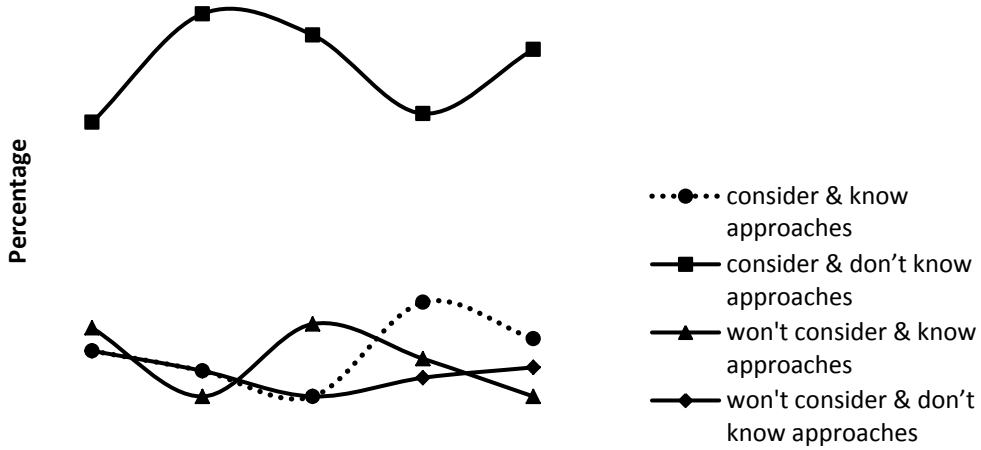
feasibility reports for your greenway projects", 28 answered "no", and 21 answered "not sure". To the question "will you suggest the clients hire ecologists for greenway planning", 89.2% of the 102 respondents answered "yes", 3.9% answered "no", and 6.9% answered "not sure". However, among the 67 respondents with greenway experience, only 22 answered "yes" to the question "have any ecologists joined in your projects", 31 answered "no", and 13 answered "not sure". These revealed the difference between the ideal and the reality, and proved that ecological issues were not paid enough attention. Moreover, the trail, greenway along road, and greenway along water had the highest percentages of all planning projects, respectively 30%, 29% and 28% (Fig. 6), but greenway along road and water are vulnerable to species invasion.

**Fig. 6.** Geographical types of greenways



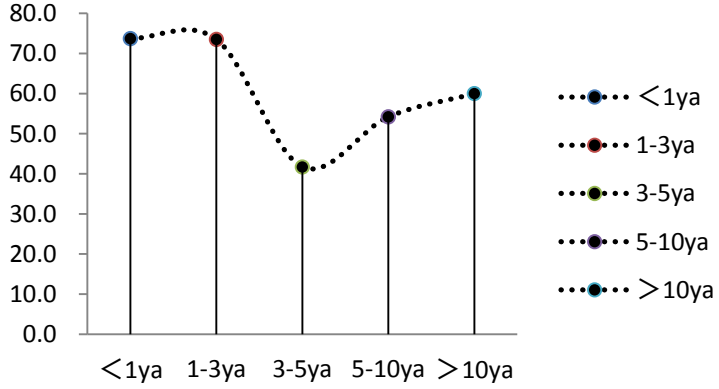

To answer the question "will you consider species invasion in greenway planning", 79.4% of the 102 respondents chose "yes", 9.8% chose "no", and 10.8% chose "not sure". To the question "will you consider preventive approaches if your greenway have potential invasion", 10.8% answered "yes, and I know the approaches", 76.5% answered "yes, but I don't know the approaches", 6.9% answered "no, but I know the approaches", and the rest answered "no, and I don't know the approaches". It showed that majority of the respondents will consider preventive approaches, but 87.6% of them don't know the approaches. For their working experience, 21.7% respondent with 5-10 year experience would consider and know the preventive approaches, followed by those with over 10 year experience. It revealed that greenway planners with longer experience would consider more and know better (Fig. 7). 88.2% of the respondents with 1-3 year experience, higher than other ones, would consider preventive approaches but they didn't how to do. It showed that planners worked 1-3 years began to concern the issues, unfortunately, they knew little to prevent.

**Fig. 7.** Knowledge of preventive methods analyzed with working experience




To the question "will you suggest your clients cancel it, if your greenway planning project is potential to be invaded and the invasion is hard to be solved", 64.7% of the 102 respondents answered "yes", and 31.4% answered "no", and 3.9% answered "not sure". Considered the seriousness of species invasion, 31.4% is a large proportion, in contrast to the respondents' concern to ecological and invasion issues. For the working experience (Fig. 8), most respondents with 1-3 or less than 1 year experience would suggest the clients to cancel, respectively 73.7% and 73.5%. However, least respondents with 3-5 year experience, 41.7%, would do so. Higher than them, 54.2% and 60% respondents with 5-10 year or longer experience would suggest clients.

**Fig. 8.** Analysis with working experience




## Discussion and suggestion

Results proved the hypothesis that greenway planners don't have enough knowledge on bio-invasion in greenway. Although they were willing to show attention to species invasion issues in greenway projects, it couldn't be proved in their planning and by their actual attitudes.

Results also showed that plenty of greenway projects had been being extensively spread all over China. Many landscape design firms and designers surveyed did or were doing greenway projects. They were interested in greenways, and they expected greenway have a brilliant prospect in China. However, this optimism is worried by researchers, because there are lots of issues needed to study before a greenway boom.

In terms of project category, recreation is the main purpose and main function of greenways in China, because greenways are proposed to promote tourism and then rural economy. Therefore, the function of biological corridor isn′t emphasized, so that greenway planners pay not enough attention to species invasion. These have been proved by the interviews.

Landscape architects knowing the possibility of species invasion in greenways aren't in a dominant majority. Although most respondents know the severe consequence of invasion, they don't think the possibility of invasion in greenways will be high. Even though a majority of landscape architects present their intension to consider ecological and species invasion issues in planning process, most of them don't know valid methods to prevent. A considerable portion of landscape architects won't suggest clients cancel the projects which cause species invasion. This could be a dangerous sign.

Through interviews to the selected respondents, researches summed up the reasons which caused the results. First, the professional education hasn't provided enough ecological knowledge. Most landscape architects are of landscape architecture, urban planning, and environmental art majors. The former two majors offer some ecological courses, which are not core courses, but the education more emphasizes the aesthetic related skills of the students. More important, because there is no registration for landscape architects in China, anyone with visual design skills could be a landscape architect. Secondly, landscape architects lack of a comprehensive cognition of greenway. Many interviewees thought greenways are just landscape architecture projects, instead of interdisciplinary. They thought greenways were proposed for human being, so the recreational functions were most important, instead of biodiversity. Some even thought that the human activities in greenways would reduce the species invasion. Thirdly, the absence of administration and technical requirement had a negative impact on the attitudes of greenway planners. Most guidelines and standards of greenway planning by governmental agencies had no requirement to prevent potential invasion, even those having the requirement didn't provide explicit technical criteria. Thus, the planners followed the requirement, and ignored the issues not required. Last but not least, pressure of projects and financial consideration has a main impact. Because of the short time for the large greenway plans, both of the clients and planners tend to avoid ecologists, who might make the process complicated and prolong the planning time. More important, if the projects are cancelled for some reason, it means a financial loss for the greenway planners and their firms, as well as the clients. Working experience of 3-5 years is a step to promotion, and a financial loss of the firms will impact the planners' careers, so planners with this situation are not willing to suggest the clients cancel projects for species invasion.

According to the reasons above, the researchers gave suggestion as follows. First, basic knowledge of biodiversity and species invasion should be provided in the education of landscape architecture and other related majors. Also, the national professional education councils should require this ecological knowledge in the guidelines for professional education. Secondly, the greenway projects should have ecological feasibility reports, especially the contents of species

invasion and environmental effects. Ecologists should be invited to join the projects and play an irreplaceable role. Finally, administration should monitor completed greenways, in order to estimate the conditions of species invasion.

## Conclusion

Greenway is an important green infrastructure with multi-functions, and plays important roles for the integration of urban and rural areas, economic and ecological development in China. As a result, greenways are being quickly developed all over China. In this process, ecological issues including species invasion are ignored, whose consequence might be serious. Through an investigation to landscape firms and landscape architects, it was found that landscape architects have not enough knowledge of species invasion and pay less attention to this issue in greenway planning. The main reasons include lack of ecology-related education, vague definition for greenway, lack of related requirements in guidelines, as well as financial consideration and pressure of projects. Therefore, a comprehensive structure of knowledge and a strict supervision to planning process is necessary and crucial. Administrations and professional associations should issue guidelines and regulations for greenway planning and education, introduce ecologists into planning process, and more important, slow down the greenway development.

*Environmental art is a discipline focusing on ornamental landscape design and interior decoration, but there are no ecological courses involved in its educational program.

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