Management Method of Planted Plants and Immigration Plants through Monitoring on Wildflower Garden
- Case Study on Seoul Samgaksan Elementary School -

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Abstract
This study was conducted to analyze the relationship between planted plants and immigration plants by monitoring the wildflower garden constructed at Seoul Samgaksan Elementary School. The results of this study are as follows:

First, plants planted in the garden 32 taxa, except for weakened only 1 taxa (Clematis patens), the remaining plants maintained or increased their populations. Among maintained Plants, that did not volume growth were 6 taxa and volume growth on the spot were 5 taxa. 15 taxa were spread around the planting area and 5 taxa spread sporadically to unpredictable areas other than the planting area. Although most of the planted plants show good growth, no special management is required, but Lonicera japonica needs the density management that cuts off the stem in the early spring and 5 sporadically spreading taxa, the planting intent of garden is attenuated, so remove the root when new leaves come out in spring.

Second, the total number of plants transferred after 2 years of wildflower garden constructed were 83 taxa total, which is 2.6 times that of planted plants. The seed disseminule form was analyzed as 52% barochory, 27% anemochory & hydrochory, 16% autochory and 5% zoochory. Also about 43% of the transferred plants were estimated to been imported from soil seed bank.

Third, we classified immigration plants into largely native plants and naturalized plants. The native plants were transferred to more than naturalized plants: 65 native plants, 1 cultivated plants and 17 (22%) naturalized plants. The results of the monitoring of the rooftop garden ‘Choroktteul’ in Seoul City Hall showed that there were differences in the type and number of the immigration plants depending on the distance and quality of the surrounding greenery.

Fourth, the management method of immigration plants is divided into three categories: elimination, transplantation, and utilization. The 39 taxa were selected for the elimination: Invasive alien plants among naturalized plants, fast spreading plants, plants that expand sideways with rhizomes, and plants that interfere with the growth of planted plants: grow to over 1 meter in height and climbing plant. The elimination period should be dry, clear, windy day, remove the root without any residue. The transplanted plants are 18 taxa, tree, plants not suitable for habitat, and in elementary school textbooks. It is a group of 26 taxa which are used in the garden: for landscape that plants have ornamental values (flowers, leaves, and autumn colors etc.) but do not attenuate the intent of the garden, and for groundcover that plants have low plant height and fast spread. It is also possible to prevent immigration plants when you are mulching or planting plants densely populated areas when making a garden.

Key words: density management, plants management method, seed distribution type, quality of surrounding green space

I. Introduction
A garden is a space created by humans, not wild nature, and it continues to change its appearance yearly and seasonally. Gardens consist of plants that change over time as main materials, thus requiring continuous management. When gardens are filled more with immigration plants than planted plants, their original forms and the intention of creation can be reduced. Some species of immigration plants, however, play a positive role in being a source of feed for wild birds and fish, and habitats, and resources for medicine, food or fertilizer, and preventing soil loss, and they also act as an important element for biodiversity. Therefore, it is necessary to manage immigration plants individually based on the accurate information on their species.

Studies on immigration plants can be divided into three groups. The first one is about immigration plants in natural
spaces, including those on the distribution of naturalized plants and immigration plants in natural ecosystems, and those on monitoring resources in national parks. The second one is about immigration plants in planned spaces, and studies in the second group were conducted mainly in large-scale parks, such as Gildong Ecological Park (Kim et al., 2000), Yeouido Saetgang Ecological Park (Choi and Lee, 2001), and World Cup Park (Son, 2004). The third group is on the management of plants in gardens, including a study on the management methods of planted plants and invasive plants through monitoring a rooftop garden in Seoul City Hall (Choi et al., 2003), and a study on the characteristics of immigration plants (Jang et al., 2010).

Since the ‘Act on the Creation and Furtherance of Arbore- tumns and Gardens’ was enacted in July, 2015, a series of garden expos were held in Korea, gaining attention from the public. At this point of time, it is necessary to conduct studies on methods of continuously maintaining gardens at a low cost with little management efforts in order to establish a gardening culture in daily life. It is necessary to remove immigration plants, viewing them as weeds, but it is also important to understand the characteristics of such plants and use them wisely, which changes gardens gradually into spaces harmonized with surrounding environments.

Against this backdrop, this study aims to monitor a wildflower garden in an elementary school in Seoul; analyze whether wild plants planted in the garden can grow well for a long time; examine immigration plants; and observe the relationship between planted plants and immigration plants. Based on the results, methods of managing plants in wildflower gardens created in urban areas are suggested in this study.

II. Research Methods

1. Subjects

   This study was conducted at a wildflower garden (name as ‘Wildflower Garden Feeling the Wind”) created at Seoul Samgaksan Elementary School (141, Samyang-ro 19-gil, Gangbuk-gu, Seoul). The garden was constructed by the Korea National Arboretum within a large-scale apartment complex redeveloped in Samgaksan-dong (Mia 6 and 7 dongs), Gangbuk-gu in July, 2015. The site around the survey area and statue is shown in Fig. 1.
Table 1. Seoul Samgaksan Elementary School wildflower garden planting plants statue.

<table>
<thead>
<tr>
<th>Family name</th>
<th>Scientific name / Korean Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinaceae</td>
<td>Abies koreana Wilson</td>
</tr>
<tr>
<td></td>
<td>소나무과 구상나무</td>
</tr>
<tr>
<td>Cornaceae</td>
<td>Cornus alba L.</td>
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<td></td>
<td>중풍나무과 항란재나무</td>
</tr>
<tr>
<td>Caprifoliaceae</td>
<td>Lonicera japonica Thunb.</td>
</tr>
<tr>
<td></td>
<td>인동과 인동동풍</td>
</tr>
<tr>
<td>Ranunculaceae</td>
<td>Aquilegia huoergiana var.</td>
</tr>
<tr>
<td></td>
<td>oxysepala (Trautv. &amp; Meyer) Kitam.</td>
</tr>
<tr>
<td></td>
<td>미나리아재비과 까치복수초</td>
</tr>
<tr>
<td></td>
<td>Clematis patens C.Morren &amp; Deene.</td>
</tr>
<tr>
<td></td>
<td>구상나무과 모란오리</td>
</tr>
<tr>
<td></td>
<td>Adonis amurensis var. ramosa Makino</td>
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<tr>
<td></td>
<td>가지복수초</td>
</tr>
<tr>
<td>Juncaceae</td>
<td>Juncus effusus var. decipiens</td>
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<tr>
<td></td>
<td>꼼풀과 꼼풀</td>
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<tr>
<td>Compositae</td>
<td>Aster maackii Regel</td>
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<td>국화과 줄개미취</td>
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<tr>
<td></td>
<td>Dendranthema zawadskii var. tenuisectum Kitag.</td>
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<tr>
<td></td>
<td>포천구절초</td>
</tr>
<tr>
<td>Labiatae</td>
<td>Thymus quinquecostatus Celak.</td>
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<tr>
<td></td>
<td>벽리향</td>
</tr>
<tr>
<td>Crassulaceae</td>
<td>Hylotelephium erythrostictum (Miq.) H.Ohba</td>
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<tr>
<td></td>
<td>돌나물과 꿩의비름</td>
</tr>
<tr>
<td>Lilaceae</td>
<td>Hemerocallis fulva (L.) L.</td>
</tr>
<tr>
<td></td>
<td>밤꽃과 원추리</td>
</tr>
<tr>
<td>Saxifragaceae</td>
<td>Astilbe rubra Hook.f. &amp; Thomas ex Hook.f.</td>
</tr>
<tr>
<td></td>
<td>범의귀과 노무오중</td>
</tr>
<tr>
<td>Gramineae</td>
<td>Pennisetum alopecuroides (L.) Spreng.</td>
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<tr>
<td>Lythraceae</td>
<td>Lythrum salicaria L.</td>
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<td>Iridaceae</td>
<td>Iris setosa Pall. ex Link</td>
</tr>
<tr>
<td></td>
<td>부채붓꽃</td>
</tr>
<tr>
<td>Cyperaceae</td>
<td>Carex japonica Thunb.</td>
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<tr>
<td></td>
<td>사초과 개벽리사초</td>
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<tr>
<td></td>
<td>Carex spicata (H. &amp; Arn.)</td>
</tr>
<tr>
<td></td>
<td>밑사초</td>
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<td>Caryophyllaceae</td>
<td>Arenaria junccea M.Bieb.</td>
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<td>석죽과 벼룩이울타리</td>
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<td>벚꽃과 영초</td>
</tr>
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<td>Rosaceae</td>
<td>Duschenea indica (Andr.) Focke</td>
</tr>
<tr>
<td></td>
<td>장미과 백리향</td>
</tr>
<tr>
<td></td>
<td>Aruncus aethusfolius (H.Lév.)</td>
</tr>
<tr>
<td></td>
<td>백리향</td>
</tr>
<tr>
<td>Campanulaceae</td>
<td>Platycodon grandiflorum (Jacq.)</td>
</tr>
<tr>
<td></td>
<td>초롱꽃과 도라지</td>
</tr>
<tr>
<td>Scrophulariaceae</td>
<td>Veronica linirifolia Pall. ex Link</td>
</tr>
<tr>
<td></td>
<td>현상과 고리환</td>
</tr>
<tr>
<td>Fumariaceae</td>
<td>Dicentra spectabilis (L.) L. em.</td>
</tr>
<tr>
<td></td>
<td>현호색과 금상화</td>
</tr>
</tbody>
</table>

2014. A fragmented green space at the foot of Bukhan Mountain is situated in the southern side of the elementary school, and the eastern, western and northern sides of the elementary school are surrounded by the apartment complex (Fig. 1). The playground of the school is located on the third floor of the building, and the floor is mostly made of concrete only with a very small green space. The elementary school shares its main gate with a middle school. The wildflower garden is created on the concrete floor (10.3×5.3×0.45 m) in an inner court surrounded by buildings, and the walls of the planting space were built with volcanic stone bricks. In the garden, 32 taxa1) of native plants (20 families, 28 genera) were planted (Table 1).

2. Methods

The wildflower garden was monitored in June and September, 2016, two years after the creation of the garden, when the growth and development of plants are most noticeable and all the weeds that grow in spring, summer and autumn can be observed. All the species of plants that were planted in the garden and other plants that were observed were surveyed, and their height and population, the coverage of planted plants and immigration plants, and their growth and development status (emergence, blooming, fruiting, seed disseminule form and withering) were recorded and photographed. In addition, to identify the route of introduction of immigration plants, plants that were observed within 500m from the garden (flower beds within the school, residential areas, streets, surrounding mountain areas) were also surveyed (Fig. 1). The life forms and disseminule forms of immigration plants were also analyzed to collect their information. The surveyed plants were identified and classified based on Coloured Flora of Korea (Lee, 2003) and New Illustrations and Photographs of Naturalized Plants of Korea (Park, 2009), and listed according to the Korean Plant Names Index (Nature, 2017). The life forms and disseminule forms of the observed plants were rearranged based on Lineamenta Florae Coreae (Lee, 1996).

1) Taxa were not classified based on the existing classification scheme (Kingdom-Phylum-Class-Order-Family-Genus-Species), but listed by individual classification units (Operational Taxonomic Unit, OTU) that refer to the objects to be studied. These individual classification units may include species, subspecies, and variety.
III. Results and Discussion

1. Monitoring planted plants

The 32 taxa of plants planted by the Korea National Arboretum in July, 2014 were all native plants that can grow in temperate regions in the middle part of Korea. In particular, considering the windy environment in the location, 6 grass taxa with high environmental adaptability (5 Cyperaceae species, 1 Gramineae species) were planted to ensure people feel the directions of wind like the main concept of the garden (Fig. 2).

The results of monitoring showed that most of the planted plants grew well, but *Clematis patens* C. Morren & Decne. was weakened, indicating that the species failed to survive in the competition with *Lonicera japonica* Thunb., planted along the species. In addition, one of the five *Abies koreana* Wilson trees withered one year after planting, but the rest 4 trees grew well, which indicates that the tree withered due to other reasons than environmental conditions.

Most species maintained or increased their population, and those that maintained their populations but showed no growth in thickness were 6 taxa including *Abies koreana* Wilson, *Hylotelephium erythrostictum* (Miq.) H.Ohba, *Iris setosa* Pall. ex Link, *Adonis amurensis* var. *ramosa* Makino, *Primula sieboldii* E.Morren, and *Dicentra spectabilis* (L.) Lem. Those
that maintained their population, and showed a growth in thickness were 5 taxa (Mukdenia rossii (Oliv.) Koidz, Duchesnea indica (Andr.) Focke, Carex lanceolata Boott, Carex boottiana Hook. & Arn., and Carex boottiana Hook. & Arn.), and among them, Mukdenia rossii (Oliv.) Koidz. and Cyperaceae species planted along the sides of native rocks grew in thickness only without increase in population. Those that showed increase in population were divided into two groups based on their dispersion patterns as follows: first, those that spread out near the area where they were originally planted, and second, those that were sporadically dispersed beyond the area. The first group included 15 taxa (Cornus alba L.; Lonicera japonica Thunb; Aquilegia nigerican var. oxysepa (Trautv. & Meyer) Kitam.; Ranunculus japonicus Thunb; Pulsatilla koreana (Yabe ex Nakai) Nakai ex Mori; Juncus effusus var. decipiens Buchenau; Thymus quinquecostatus Celak.; Hemerocallis fulva (L.) L.; Pennisetum alopecuroides (L.) Spreng; Lythrum salicaria L.; Carex japonica Thunb.; Carex aphanolepis Franch. & Sav.; Arenaria juncea M.Bieb.; Aruncus aethusifolius (H.Lév.) Nakai; Platycodon grandiflorum (Jacq.) A.DC.), and Lonicera japonica Thunb. covered almost all the wood fences, showing a noticeable extension their brachyblast. The second group included 5 taxa (Aster maackii Regel; Dendranthema zawadskii var. temusectum Kitag.; Astilbe rubra Hook.f. & Thomas ex Hook.f.; Lysimachia clethroides Duby; Veronica linariifolia Pall. ex Link) (Table 2).

2. Monitoring immigration plants

The results of monitoring immigration plants are as follows. In June, 51 taxa, and in September, 67 taxa of immigration plants were observed, and among them, 35 taxa overlapped. The number of immigration plants 2 years after the creation of the garden was 83 taxa in total, 2.6 times the number of planted plants (32 taxa).

The life forms of immigration plants observed in this study include annual plants (37 taxa, including winter annual plants), biennial plants (7 taxa), and perennial plants (33 taxa). Most of them were herbaceous plants, but 6 taxa of arbor plants were also observed (Fraxinus rhynchophylla Hance; Acer tataricum subsp. ginnala (Maxim.) Wsl.; Nandina domestica Thunb.; Zanthoxylum schinifolium Siebold & Zucc.; Spiraea prunifolia f. simpliflora Nakai; Celastus orbiculatus Thunb.). Among the immigration plants observed in this study, Compositae species were observed most (20 taxa, 24%), followed by Gramineae species (11 taxa, 13%), and Cyperaceae (5 taxa, 6%) and Polygonaceae species (5 taxa, 6%).

In terms of population, immigration plants were reclassified into 4 types based on the disseminate forms as follows: anemochory & hydrochory, zoochory, autochory, and barochory (Lee, 1996). Those that showed two disseminate forms were recorded twice. Those of the barochory type accounted for 52%, followed by the anemochory & hydrochory type (27%), the autochory type (16%), and the zoochory type (5%) (Table 3). Weedy immigration plants can survive for a long time under

Table 2. Wildflower garden planting plants monitoring results.

<table>
<thead>
<tr>
<th>Num. of plants</th>
<th>Degree</th>
<th>Scientific name / Korean Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease Weakness</td>
<td>Clematis patens C. Morren &amp; Deene. 큰꽃오리아리</td>
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<tr>
<td>Maintain</td>
<td>Abies koreana Wilson 구상나무, Hylotelephium erythrostictum (Miq.) H.Ohba 꿀벌비름, Iris setosa Pall. ex Link 부재 몽的地图, Adonis ramosa Franch. 가지복수초, Primula sieboldii E.Morren 영초, Dicentra spectabilis (L.) Lem. 급남화</td>
<td></td>
</tr>
<tr>
<td>Volume length growth</td>
<td>Mukdenia rossii (Oliv.) Koidz. 들만종, Duchesnea indica (Andr.) Focke 밤말기, Carex lanceolata Boott 그늘사초, Carex boottiana Hook. &amp; Arn. 밀사초, Carex boottiana Hook. &amp; Arn. 밀사초(부뤄증)</td>
<td></td>
</tr>
<tr>
<td>Increase Spread out near</td>
<td>Cornus alba L. 한라개승마, Lonicera japonica Thunb. 인동덩굴, Aquilegia nigerican var. oxysepa (Trautv. &amp; Meyer) Kitam. 해바라기, Ranunculus japonicus Thunb. 미나리야재비, Pulsatilla koreana (Yabe ex Nakai) Nakai ex Mori 할미꽃, Juncus effusus var. decipiens Buchenau 길풀, Thymus quinquecostatus Celak. 백리향, Hemerocallis fulva (L.) L. 원추리, Pennisetum alopecuroides (L.) Spreng. 수크령, Lythrum salicaria L. 밀사초, Arenaria juncea M.Bieb. 바둑이올타리, Aruncus aethusifolius (H.Lév.) Nakai 한라개승마, Platycodon grandiflorum (Jacq.) A.DC. 도라지</td>
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<td>Sporadically dispersed</td>
<td>Aster maackii Regel 종개미취, Dendranthema zawadskii var. temusectum Kitag. 포천구절초, Astilbe rubra Hook.f. &amp; Thomas ex Hook.f. 노루오줌, Lysimachia clethroides Duby 큰까치수염, Veronica linariifolia Pall. ex Link 코리플</td>
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<tr>
<td>Life form</td>
<td>Taxonomic Name / Scientific name</td>
<td>Naturalized plants</td>
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<td>-----------</td>
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</tr>
<tr>
<td><strong>Tall tree</strong></td>
<td><em>Fraxinus rhynchophylla</em> Hance 물푸레나무</td>
<td>1</td>
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<tr>
<td></td>
<td><em>Acer tataricum</em> subsp. giroula (Maxim.) Weems. 신나무</td>
<td>2-5</td>
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<tr>
<td><strong>Shrub</strong></td>
<td><em>Zanthoxylum schinifolium</em> Siebold &amp; Zucc.</td>
<td>1</td>
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<td><em>Spiraea prunifolia</em> f. simpliciflora Nakai 소립나무</td>
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<td><strong>Climbing tree</strong></td>
<td><em>Celastrus orbiculatus</em> Thunb. 노박덩굴</td>
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<td><strong>Annual plants</strong></td>
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<td><em>Rorippa indica</em> (L.) Hiern 개갓냉이</td>
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<td><em>Panicum bisulcatum</em> Thunb. 개기장</td>
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<td><em>Erigeron annuus</em> (L.) Pers. 개망초</td>
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<td><em>Persicaria longiseta</em> (Bruijn) Kitag.</td>
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<tr>
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<td><em>Persicaria thunbergii</em> (Siebold &amp; Zucc.) H.Gross ex Nakai 고마리</td>
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<td><em>Cyperus microiria</em> Steud. 금방동사니</td>
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<td><em>Microstegium vimineum</em> (Trin.) A.Camus 나도바랭이새</td>
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<td><em>Echinochloa crusgalli</em> (L.) P.Beauv. 돌피</td>
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<td><em>Conyza canadensis</em> (L.) Cronquist 찬나영</td>
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<td><em>Stellaria alsine</em> var. undulata (Thunb.) Ohwi 비싸나물</td>
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<td><em>Amaranthus palmeri</em> (L.) DC. 포리아</td>
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<td><em>Veronica arvensis</em> L. 선개불알풀</td>
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### Table 3. (Continued)

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<th>Life form</th>
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<th>Num. of plants</th>
<th>Disseminule form</th>
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<td>Crepidium strumosum (Bunge) Pak &amp; Kawano</td>
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<td>anemochory &amp; hydrochory</td>
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<td>barochory</td>
<td>(assumption)</td>
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Table 3. (Continued).

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<th>Life form</th>
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<th>Num. of plants</th>
<th>Disseminate form</th>
<th>Origin from immigration plants</th>
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<tr>
<td>Biennial</td>
<td>Glycine soja Siebold &amp; Zucc.</td>
<td>동콩</td>
<td>2-5</td>
<td>autochory</td>
<td>Flower bed within the school</td>
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<tr>
<td>climbing plants</td>
<td>Amphicarpaea bracteata subsp. edgeworthii (Berth.) H.Ohashi</td>
<td>새콩</td>
<td>2-5</td>
<td>autochory</td>
<td>Residential area &amp; Streets</td>
</tr>
<tr>
<td></td>
<td>Vigna angularis var. nipponensis (Ohwi) Ohwi &amp; H.Ohashi</td>
<td>새팥</td>
<td>2-5</td>
<td>autochory</td>
<td>Surrounding mountain areas</td>
</tr>
<tr>
<td></td>
<td>Humulus japonicus Siebold &amp; Zucc.</td>
<td>환삼덩굴</td>
<td>2-5</td>
<td>autochory</td>
<td>Soil seed bank (assumption)</td>
</tr>
<tr>
<td>Perennial</td>
<td>Metaplexis japonica (Thunb.) Makino</td>
<td>박주가리</td>
<td>2-5</td>
<td>anemochory &amp; hydrochory</td>
<td></td>
</tr>
<tr>
<td>climbing plants</td>
<td>Dioscorea nipponica Makino</td>
<td>부채마</td>
<td>2-5</td>
<td>anemochory &amp; hydrochory</td>
<td></td>
</tr>
</tbody>
</table>

the ground (Rural Development Administration National Institute of Agricultural Sciences, 2008), and most of the immigration plants observed in an artificially created area in early years are grown from buried seeds. Although many species of the barochory type were observed in this study, the share of those of the anemochory & hydrochory type is expected to gradually increase over time as more species immigrated from surrounding areas (Jang et al., 2010).

To trace their route of introduction, plants that were observed within 500m from the wildflower garden in the elementary school were surveyed, and the results show that out of 83 taxa of immigration plants, 49 taxa were observed near the garden as follows: 25 taxa in flower beds within the school; 28 taxa in residential areas and on streets; 22 taxa in surrounding mountain areas (including overlapping species). The rest 34 taxa were not observed near the garden. Out of the species of which immigration routes were not identified, 2 taxa seemed to be introduced from surrounding mountain areas, 4 taxa from residential areas and streets, and 28 taxa from buried seeds that were brought with planted plants considering the disseminule forms of seeds and the ecology of plants. Among the immigration plants observed in this study, 8 taxa that showed the barochory and hydrochory types were observed in surrounding mountain areas, but it is difficult to assume that they were introduced from there within a short period of time, like 2 years. Thus, they are expected to grow from buried seeds.

Immigration plants are largely grouped into native plants and naturalized plants, and in this study 65 taxa of native plants, 1 taxon of cultivated plant, and 17 taxa of naturalized plants (22%) were observed, more indicating native plants immigrated than naturalized plants. Out of the 17 taxa of naturalized plants, the disseminule form of 11 taxa is the anemochory & hydrochory type, and they, except Veronica arvensis L., were all distributed in surrounding areas, indicating a high possibility of immigration from surrounding areas. Aster subulatus var. sandwicensis A.G.Jones, Ambrosia trifida L., Aster pilosus Willd., and Eupatorium rugosum Houtt. showed naturalized degree 4 (distributed in a limited area, but with large population) or 5 (cosmopolitan species with large population). They are categorized into the 3rd stage of immigration (from 1964 to present), and thus they need to be monitored continuously (Park, 2009).

The results of monitoring the rooftop garden ‘Choroktteul’ in Seoul City Hall showed that there were more naturalized plants than native plants (Choi et al., 2003). The rooftop garden is located in downtown and surrounded by high-rise buildings, and it was created on a rooftop in an open environment with 10 cm deep soil. There is a stream (Cheonggyecheon (Stream) restoration) within 500 m from the garden, and green spaces at the foot of Inwang Mountain are 800 m away from the garden. For these reasons, unlike the wildflower garden, the target of this study, more naturalized plants seemed to be observed in the study. In the target of this study, unlike the Choroktteul rooftop garden, many native plants were introduced which is attributable to the fact that a fragmented green space at the foot of Bukhan Mountain is located in the southern side of the garden. The results of the monitoring the wildflower garden ‘Wild Flower Garden Starting from Landfill’ located within Pyeonghwa Park in World Cup Park in Sangam-dong, Seoul showed that 38% of immigration plants were naturalized
plants and 62%, native plants. This indicates a possibility of using native plants that immigrated from other places as gardening materials in a garden created with native plants. In addition, in an study on the immigration plants in the Garden of the Korea National Arboretum (Nam et al., 2017), over 75% of immigration plants were found to be introduced from the Gwangneung forest located close to the garden, which shows that the number and population of immigration plants are greatly affected by the distance from and the quality of surrounding green spaces.

3. Methods of managing plants in gardens

1) Managing planted plants

As the results of monitoring planted plants show in Table 4, except *Clematis patens* C.Morren & Decne. of which population decreased, most of the planted plants grew well, and thus they did not require any special management. However, in the case of those that grew rapidly and are sporadically dispersed beyond the areas where they were originally planted, their population density needs to be managed to prevent the reduction of the intention of gardens. Population density can be relatively easily controlled by taking action at a seedling stage in early years.

*Clematis patens* C.Morren & Decne. was the only species of which population decreased, and planted along with *Lonicera japonica* Thunb. Some leaves of *Lonicera japonica* Thunb. remained green even in winter, and it can grow well in any environment including shade, dry lands, rock fields, and coastal reclaimed lands. *Lonicera japonica* Thunb. is so prolific that just one tree can turn a whole village into a forest of *Lonicera japonica* Thunb. (Choi, 1997), and thus it seemed to suppress the growth and development of *Clematis patens* C.Morren & Decne. that was planted along with it. Runners of this excessively prolific plant grew on the ground and into the areas where *Clematis patens* C.Morren & Decne. was planted, and the runners have to be cut out in early spring to control its population density and to ensure visitors to see flowers of both plants.

There were 5 taxa that were sporadically dispersed beyond the planted areas into unpredictable areas (*Aster maackii* Regel; *Dendranthema zawadskii* var. *temuisectum* Kitag.; *Astilbe rubra* Hook.f. & Thomas ex Hook.f.; *Lysimachia clethroides* Duby; *Veronica linariifolia* Pall. ex Link). It is important to pull such species up by the roots when their new leaves are out in spring. In the case of Compositae plants within the planted areas (*Aster maackii* Regel, *Dendranthema zawadskii* var. *temuisectum* Kitag.), their stems or branch tips, that is, their growing points, should be cut out to let axillary buds and side shoots grow using a shoot-top-cutting technique. By doing so, planted spaces can be filled with luxuriant plants (Korea National Arboretum, 2015).

2) Managing immigration plants

Methods of managing immigration plants including nonnative plants can be divided, depending on management materials and means, into ecological, physical, biological and chemical management types (Rural Development Administration National Institute of Agricultural Sciences, 2008). In this study, physical management methods are suggested only.

In this study, three types of physical management methods for immigration plants are suggested as follows: elimination,

<table>
<thead>
<tr>
<th>Plants spread out near</th>
<th>Case</th>
<th>Scientific name / Korean Name</th>
<th>Management Method</th>
<th>Time</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Lonicera japonica</em> Thunb.</td>
<td>Thinning</td>
<td>Cut the stem creeping the ground Cut the stem that extends to <em>Clematis patens</em> planting area</td>
<td>Early spring, (Early March)</td>
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<td></td>
</tr>
<tr>
<td>Plants sporadically dispersed beyond the area</td>
<td><em>Dendranthema zawadskii</em> var. <em>tenuisectum</em> Kitag.</td>
<td>Pulling up or Transplanting</td>
<td>Plants that have spread to areas outside the planting area Pulling up the roots or Transplanting</td>
<td>Mid-March, when new leaves come out</td>
<td>Plants in the planting area, shoot-top-cutting</td>
</tr>
<tr>
<td><em>Lysimachia clethroides</em> Duby</td>
<td></td>
<td></td>
<td></td>
<td>May, When new leaves come out</td>
<td></td>
</tr>
<tr>
<td><em>Aster maackii</em> Regel</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Astilbe rubra</em> Hook.f. &amp; Thomson</td>
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<tr>
<td><em>Veronica linariifolia</em> Pall. ex Link</td>
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</tbody>
</table>

Table 4. Management method of wildflower garden’s planting plants.
transplanting and utilization. Those that did not meet the original plans and intention of the garden should be eliminated or transplanted into other places, and those that did not reduce the intention and threat the ecosystem of the garden can be utilized in the garden.

Those that have to be eliminated include invasive alien plants among naturalized plants; fast spreading plants; plants that expand sideways with rhizomes; and plants taller than 1m and climbing plants that interfere with the growth of planted plants. Invasive alien plants among naturalized plants are species that cause serious risk to ecosystem, etc., and they need to be controlled under 'the Act on the Conservation and Utilization of Biological Diversity'. In the wildflower garden in this study, 4 taxa were observed (*Ambrosia trifida* L.; *Aster pilosus* Wild.; *Eupatorium rugosum* Houtt.; *Rumex acetosella* L.) and they should be immediately removed as soon as they are found. Fast spreading plants include 19 taxa (*Setaria viridis* (L.) P.Beauv.; *Panicum bisulcatum* Thunb; *Erigeron annuus* (L.) Pers.; *Acalypha australis* L.; *Microstegium vimineum* (Trin.) A.Camus; *Echinochloa crusgalli* (L.) P.Beauv.; *Conyza canadensis* (L.) Cronquist; *Digitaria violascens* Link; *Digitaria ciliaris* (Retz.) Koel.; *Erechtites hieracifolia* Raf.; *Veronica arvensis* L.; *Euphorbia supina* Raf.; *Aster subulatus* var. *sandwicensis* A.G.Jones; *Galinsoga ciliata* (Raf.) S.F.Blake; *Sonchus oleraceus* L.; *Setaria faberii* Herrm.; *Agropyron tsukushiense* var. *transiens* (Hack.) Ohwi; *Erigeron philadelphicus* L.; *Taraxacum officinale* Weber). If they are not removed at a seedling stage, they spread exponentially, so that it becomes difficult to control their population. Therefore, they should be eliminated when they start to flower in spring. Plants that expand sideways with rhizomes include 5 taxa (*Equisetum arvense* L.; *Artemisia princeps* Pamp.; *Rumex acetosella* L.; *Poa pratensis* L.; *Trifolium repens* L.), and it is important to completely eliminate the plants including roots. In particular, *Equisetum arvense* L. spreads and puts down root deep into the ground so quickly that it becomes very difficult to remove it later unless controlling at an early stage. Therefore, it should be immediately removed as soon as they are found before their sporangium cones disperse spores in early spring. *Trifolium repens* L. is a familiar plant to people as it is introduced in elementary school textbooks. Some can be transplanted to use as a learning material for students, and the rest should be all removed. Since it expands sideways, it should be managed within a container to prevent its roots from going farther. Plants taller than 1m (5 taxa including *Panicum bisulcatum* Thunb.; *Echinochloa crusgalli* (L.) P.Beauv.; *Aster subulatus* var. *sandwicensis* A.G.Jones; *Sonchus oleraceus* L.; *Setaria faberii* Herrm.) are indistinguishable from planted plants, and thus they should be eliminated at an early stage to maintain the intention of planting. Climbing plants (6 taxa including *Glycine soja* Siebold & Zucc.; *Amphicarpaea bracteata* subsp. *edgeworthii* (Benth.) H.Ohashi; *Vigna angularis* var. *nipponensis* (Ohwi) Ohwi & H.Ohashi; *Humulus japonicus* Siebold & Zucc.; *Metaplexis japonica* (Thunb.) Makino; *Dioscorea nipponica* Makino) also interfere with the growth of planted plants, and should be removed. Dry, sunny and windy days, not rainy days are suitable for removing plants, because the wind can quickly evaporate moisture in weeds rooted out, and keep them from taking root in the ground again (Oh, 2009).

Transplanted plants are removed from the wildflower garden to maintain the original plan and intention of the garden, but they can be utilized elsewhere. They include tree plants, plants not suitable for the habitat, and plants introduced in elementary school textbooks. In the case of tree plants, they are likely to naturally die out from a long-term perspective, and also to grow taller than the capacity of the garden, and thus they need to be transplanted into other environments suitable for them at an early stage. Plants that are not suitable for the habitat of the garden were 2 taxa including *Persicaria thunbergii* (Siebold & Zucc.) H.Gross ex Nakai, and *Pilea mongolica* Wedd. Since they grow in wet areas, they seem to grow from buried seeds. They can be utilized as scenic materials, and thus need to be transplanted into other environments suitable for their growth and development. Meanwhile, as the target of monitoring in this study is a garden in an elementary school, plants that are introduced in elementary school textbooks (Reu, 2016) can be used for educational purposes to increase the effectiveness of learning. In the case of *Setaria viridis* (L.) P.Beauv., as it spreads very quickly, it is necessary to pull it up by the roots after transplanting some for educational purposes.

Among immigration plants, those that can be maintained and utilized in the garden can be divided into landscaping and ground-covering types. Plants for landscaping should have ornamental values in their flowers, leaf colors and textures,
and autumn leaf colors, and do not reduce the intention of gardens. In the wildflower garden monitored in this study, 21 taxa can be utilized for landscaping. Plants for ground-covering are usually of short height (20 cm or shorter), spread quickly and have shallow roots. In the wildflower garden, 16 taxa can be maintained and utilized (Table 5).

IV. Conclusions

As gardens use plants as main materials, they continue to change their appearance yearly and seasonally. To maintain the original forms and intention of gardens, continuous management is essential. This study aimed to monitor a wildflower garden created at Seoul Samgaksan Elementary School, to observe the relationship between planted plants and immigration plants, and thus to suggest methods of managing plants, and the results created at Seoul Samgaksan Elementary School, to observe the relationship between planted plants and immigration plants, and thus to suggest methods of managing plants, and the results

Table 5. Management method of wildflower garden’s immigration plants.

<table>
<thead>
<tr>
<th>Method</th>
<th>Type</th>
<th>Scientific name / Korean Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Invasive alien plants among naturalized plants</td>
<td>Ambrosia trifida</td>
<td>L. 단풍잎돼지풀, Aster pilosus Wild. 미국속부쟁이, Eupatorium rugosum Houtt. 서양풍부쟁이, Rumex acetusella L. 잎겨우수</td>
</tr>
<tr>
<td>Elimination</td>
<td>Plants that expand sideways with rhizomes</td>
<td>Equisetum arvense L. 씨도기, Artemisia princeps Pamp. 속, Rumex acetusella L. 잎겨우수, Poa pratensis L. 황포아, Trifolium repens L. 토끼풀</td>
</tr>
<tr>
<td>Plants that interfere with the growth of planted plants</td>
<td>Tall Plants (more than 1 m)</td>
<td>Panicum bisulcatum Thunb. 개기장, Echinocloa crusgalli (L.) P.Beauf. 돌세, Aster subulatus var. sandwicensis A.G.Jones 검바랭이풀, Sonchus oleraceus L. 방광초, Setaria faberii Herrm. 자주강아지풀</td>
</tr>
<tr>
<td>Climbing plant</td>
<td>Glycine sojo Siebold &amp; Zucc. 돌세, Ampeloprasa bracteata subst. edgeworthii (Benth.) H.Ohashi 새찰, Viola angularis var. nipponensis (Ohwi) Ohwi &amp; H.Ohashi 새찰, Humulus japonicus Siebold &amp; Zucc. 홀란잎고, Metaplexis japonica (Thunb.) Makino 박수가, Diocoreoa nipponica Makino 바랭이부쟁이</td>
<td></td>
</tr>
<tr>
<td>Transplanting</td>
<td>Tree</td>
<td>Fraxinus rhynchophylla Hanse 돌록나무, Acer tataricum subst. ginnala (Maxim.) Wsm. 산나무, Pseudostellaria moschata. 자주강아지풀</td>
</tr>
<tr>
<td>Plants in elementary school textbooks</td>
<td>Persicaria thunbergii (Siebold &amp; Zucc.) H.Gross ex Nakai 고바라, Pilea monogyna Wedd. 도미물통이</td>
<td></td>
</tr>
<tr>
<td>Plants not suitable for habitat</td>
<td>Spirea prunifolia f. simpliciflora Nakai 조롱나무, Celastrus orbiculatus Thunb. 노포아, Celastrus orbiculatus Thunb. 노포아, Eupatorium Rugosum L. 각시초</td>
<td></td>
</tr>
<tr>
<td>Utilization</td>
<td>For landscape</td>
<td>Rorippa indica (L.) Herrn 개개ItemList, Persicaria longiseta (Kitag.) Ktak. 개개ItemList, Cyperus microirhiza Steud. 금탕사나, Youngia japonica (L.) DC. 봄바랭이, Fatsia villosa (Thunb.) Nakai 황록수, Persicaria nepalensis (Meisn.) H.Gross 줄지어, Phyllanthus ussuriensis Rupr. &amp; Maxim. 여우와리, Cephalismis demelateum (Houtt.) J.H.Pak &amp; Kawano 이로울풀, Persicaria posumbu var. latiflora (Meisn.) H.Hara 장대여, Moosia diandrae (Buch.-Ham. ex Roxb.) Maxim. 쥐꼬리풀, Cephalismis erythraea L. 쥐꼬리풀, Hypericum erectum Thunb. 고추폴, Carex neurocarpa Maxim. 장가초주, Viola collina Besser 동근비둘기풀, Pinellia ternata (Thunb.) Breitenb. 민박, Ixeris strigosa (H.Lév. &amp; Vaniot) J.H.Pak &amp; Kawano 신초박, Potentilla freyniana Borrm. 새사초절제, Aster yomena (Kitam.)Honda 숙부쟁이, Lysimachia vulgaris var. davorica (Ledeb.)R.Kunth 쥐꼬리풀, Viola verecunda A.Gray 쥐꼬리풀, Viola lactiflora Nakai 원 IDXhydrophyllum Hanse 돌록나무, Poa pratensis L. 잔바랭이풀, Molinia penaphylla L. 실제로, Mazus pumulis (Burn.f.) Steenis 수밀풀, Centaurea minima (L.) A.Br. &amp; Asch. 수밀풀가라, Agrostis clavata var. mukho Ohwi 가지식, Trigonotis pedunculata (Trevir.) Benth. ex Hemsl. 황초, Setaria litoralis (L.) Vill. 밭풀, Cerastium holostoides var. hallaitanense (Nakai) Mizoh. 산타나물, Pseudostellaria heterophylla (Miq.) Pax ex Pax &amp; Hoffm. 개발풀, Setaria italica Bunge 돌물, Allium macrostemum Bunge 산란대, Ixeris stolonifera A.Gray 쥐꼬리박, Plantago asiatica L. 장가초, Carex breviculmis R.Br. 쥐꼬리</td>
</tr>
<tr>
<td>For groundcover</td>
<td>Sellaria alinae var. undulata (Thunb.) Ohwi 바랭나물, Poa annua L. 자주강아지풀, Molinia penaphylla L. 실제로, Mazus pumulis (Burn.f.) Steenis 수밀풀, Centaurea minima (L.) A.Br. &amp; Asch. 수밀풀가라, Agrostis clavata var. mukho Ohwi 가지식, Trigonotis pedunculata (Trevir.) Benth. ex Hemsl. 황초, Setaria litoralis (L.) Vill. 밭풀, Cerastium holostoides var. hallaitanense (Nakai) Mizoh. 산타나물, Pseudostellaria heterophylla (Miq.) Pax ex Pax &amp; Hoffm. 개발풀, Setaria italica Bunge 돌물, Allium macrostemum Bunge 산란대, Ixeris stolonifera A.Gray 쥐꼬리박, Plantago asiatica L. 장가초, Carex breviculmis R.Br. 쥐꼬리, Kyllinga brevifolia Roth. 파데가리</td>
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</tr>
</tbody>
</table>
of them, except *Clematis patens* C.Morren & Decne. that was weakened, maintained or increased their populations. Those that maintained their populations but showed no growth in thickness were 6 taxa (*Abies koreana* Wilson, *Hylotelephium erythrostictum* (Miq.) H.Ohba, *Iris setosa* Pall. ex Link, *Adonis amurensis* var. *ramosa* Makino, *Primula sieboldii* E.Morren, and *Dicentra spectabilis* (L.) Lem). Those that maintained their population, and showed a growth in thickness were 5 taxa (*Mukdenia rossii* (Oliv.) Koidz, *Duchesnea indica* (Andr.) Focke, *Carex lanceolata* Boott, *Carex boottiana* Hook. & Arn., and *Carex boottiana* Hook. & Arn.). Plants that spread out near the area where they were originally planted included 15 taxa (*Cornus alba* L.; *Lonicera japonica* Thunb.; *Aquilegia buergeriana* var. *oxysepala* (Trautv. & Meyer) Kitam.; *Ramunculus japonicus* Thunb.; *Pulsatilla koreana* (Yabe ex Nakai) Nakai ex Mori; *Juncus effusus* var. *decipiens* Buchenau; *Thymus quinquecostatus* Celak; *Hemerocallis fulva* (L.) L.; *Pennisetum alopecuroides* (L.)Spreng; *Lythrum salicaria* L.; *Carex japonica* var. *ramosa* (Oliv.) Duchesnea indica (Andr.) H.Ohba, *Aruncus aethusifolius* (H.Lév.) M.Bieb.; *Primula sieboldii* E.Morren, *Adonis* var. *tenuisectum* Kitag.; *Dendranthema zawadskii* var. *tenuisectum* Kitag.; *Astrilbe rubra* Hook.f. & Thomas ex Hook.f.; *Lysimachia clethroides* Duby; *Veronica linariifolia* Pall. ex Link). Most of the planted plants have grown well, and thus they do not require any special management. However, it is necessary to cut out runners of *Lonicera japonica* Thunb. in early spring for density management. As the 5 taxa that are sporadically dispersed beyond the planted areas can reduce the intention of the garden, it is necessary to pull them out by the roots and be transplanted when their new leaves are out in spring.

Second, the number of immigration plants 2 years after the creation of the garden was 83 taxa in total, 2.6 times the number of planted plants. In terms of disseminule forms, those of the barochory type accounted for 52%, followed by the anemochory & hydrochory type 27%, the autochory type 16%, and the zoochory type 5%. Approximately 43% of the immigration plants seemed to grow from buried seeds, and thus it is important to consider that other seeds in soil can be brought with planted plants when managing gardens.

Third, immigration plants are largely grouped into native plants and naturalized plants, and in this study 65 taxa of native plants, 1 taxon of cultivated plant, and 17 taxa of naturalized plants (22%) were observed, indicating native plants immigrated more than naturalized plants. The results are inconsistent with those of monitoring the rooftop garden ‘Choroktteul’ in Seoul City Hall where naturalized plants were observed more. This indicates that the number and population of immigration plants are affected by the distance from and the quality of surrounding green spaces.

Fourth, in this study, three types (elimination, transplanting and utilization) of management methods for immigration plants were suggested. Plants that should be eliminated were 39 taxa, including invasive alien plants among naturalized plants; fast spreading plants; plants that expand sideways with rhizomes; and plants taller than 1m and climbing plants that interfere with the growth of planted plants. It is important to pull them out by the roots on dry, sunny and windy days, not rainy days at a seedling stage. Plants that should be transplanted were 18 taxa including tree plants, plants not suitable for the habitat, and plants introduced in elementary school textbooks. Plants that can be maintained and utilized in the garden were 26 taxa, including those for landscaping that have ornamental values in their flowers, leaf colors and textures, and autumn leaf colors, and do not reduce the intention of gardens, and those for ground-covering that have short height, spread quickly and have shallow roots. When creating a garden, immigration plants can be also prevented by mulching plants with barks, wood chips, straw, and coarse decomposed granite or gravels, or covering the land densely with ground-covering plants without any vacant space. In this study, physical methods of management were suggested only. As species in the wildflower garden are diversified over time, it will be necessary to develop biological management methods that use interactions between living organisms such as microorganisms, insects and allelopathy.

As this study monitored planted plants and immigration plants 2 years after the creation of the wildflower garden and suggested methods of managing the garden at an early stage only, it will be necessary to continue to monitor plants and suggest measures to manage the wildflower garden by stages.
V. References


