Making the Wageningen UR campus more beautiful

A modular plan for increasing natural diversity

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Contents

Preface and acknowledgements

This report was commissioned by Mooi Wageningen and Green Office Wageningen, and is the end-product of our ACT course, YMC-60809 at the Wageningen University, Wageningen, the Netherlands. The purpose of this report is to provide our commissioners and others interested with a description of all relevant aspects of the Wageningen UR campus, based on a literature and document study, and to give suggestions on improving the natural diversity of the Wageningen UR campus.
We hope that this report will serve as a guide and source of inspiration in making the Wageningen UR campus a place which can be enjoyed by everyone.

We would like to thank all the people who were involved in the creation and development of this project: Our commissioners from Mooi Wageningen and Green Office, Nonja Remijn, Hugo Hoofwijk and Marta Eggers, for all the background information and comments which helped us improve and create a better report. We also wish to thank all the stakeholders we interviewed and who shared their knowledge with us, bringing forth their opinions as well as good recommendations about the biodiversity at Wageningen campus and their valuable suggestions are incorporated in the final product. We also owe ir. AJ van der Have and ir. Elike Wijnheijmer, from the facility department, much gratitude with helping us understand the Natural Landscape design and upcoming plans on the Wageningen campus.
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Executive Summary

This report describes plans to improve the natural diversity at the campus of the Wageningen University and Research Centre. It is very important to keep and enhance the biodiversity on the WUR campus, because it is part of the National Ecological Network and one of the main focuses of the WUR is its living environment. Already now partially an ecological corridor crosses its land to connect two natural areas, the Veluwe and the Utrechtse Heuvelrug. The campus is quite biodiverse in terms of plant species, but its appearance is not always as diverse. Therefore, this project will look at the total *natural diversity* of the campus, which also takes aesthetics into account. The opinions of various stakeholders of the campus are described, based on surveys and personal communication with spokespersons.

A modular plan was made, based on this stakeholders analysis. The modular plan consists of several projects that can be executed individually and can be incorporated into the Wageningen campus landscape, with the aim of increasing biodiversity, ecological connectivity, functioning of the campus for its users and aesthetics of the campus. Examples of these are: an insect garden, improved wetland areas, ecological connections on several sites on the campus, flower meadows, a new meeting area and more sitting places. Some recommendations regarding the execution and monitoring of these plans will be made, such as having someone perform a more detailed analysis of abiotic factors at the site, prior to developing a new project and if possible, monitoring the efficiency of the ecological corridor across the campus.

Introduction

Wageningen UR is located in the province of Gelderland, the Netherlands, with as main focus a sustainable living environment. There are several natural areas in the vicinity, such as the Veluwe and the Utrechtse Heuvelrug. Therefore, the aim of the campus is to be a part in this natural environment as well. Wageningen campus is situated on the north side of Wageningen city to the west of the Mansholtlaan, north of sports centre De Bongerd (including some of its facilities), south of and including the Wageningen UR test fields, and east of the north-west district of Wageningen, and covers a total area of 67,5 hectares (see Figure 1)[7]. The campus is relatively new, with a concentration of buildings for education, research departments and the library. It is characterised by an open natural area in between the university buildings, with small patches of trees and bushes.
It is said that contact with nature is related with the physiological well-being of a person and may reduce stress [8], so attractive nature will cause a better working environment. However, not everybody seems to think the campus is as 'natural' as they would like to see it [3]. Improvement of the campus is possible. This report will give a description of the present natural diversity and some recommendations for the future.
We should not confuse this statement with the biodiversity status of the campus. With, for instance, approximately 60 species of grass and 70 species of trees [9], the biodiversity of the campus is quite high. A definition of biodiversity can be given as follows:

"The variability among living organisms from all ecosystems and ecological complexes of which they are part." [10].

This is something very different from the things the layman pays attention to when walking across the campus. A very biodiverse area may still look and feel very monotonous. Therefore, this report will not focus on the biodiversity of the Wageningen UR campus, but on the natural diversity thereof. Natural diversity of the campus is defined here by the aesthetics and feeling of the campus, *combined* with its biodiversity.

Figure 1. Map of Wageningen campus

The following sections will describe the natural diversity of the Wageningen campus in its various aspects. First, the current situation of the campus will be described. A comparison of the campus before the construction of Atlas and Forum, and after these buildings were finished will be made.
Then, species on campus will be compared to those living in the areas surrounding the campus. Using this comparison, the concept of an ecological corridor across the campus will be discussed.
After this, the projects which are planned on campus in the future will be discussed, and the influence of these new projects on natural diversity will be estimated.
We will provide a concise stakeholders analysis, including opinions given to us by the spokesperson for various companies on the Wageningen UR campus, the opinion of a spokesperson from the municipality, and conclusions from surveys giving the opinion of WUR students and employees.
Finally, based partially on this stakeholders' analysis, separately executable plans to improve natural diversity at the Wageningen UR campus, and to protect the natural diversity of the campus from negative effects of future projects will be made. We will call these plans the 'modular plan', since it consists of separately executable modules.

Current situation

Most of the educational facilities are located at Wageningen Campus which has old but renovated buildings and modern constructions, each with its own distinct character. The campus is a place where students, teachers, researchers and company workers meet and share ideas. It has a large, open, central area, with some park benches, grass, large ponds, trees and many views. This central area is a space where students and scientists can come together. Many wetland birds and other animals are found on the campus and also some trees and a large number of grass species are present.

The design of the campus incorporates different ecological green structures according to Maathuis and Janse 2010, as described below [1]:

- Different grass areas with short cut grass and spread areas of extensive mown grass and flower meadows.
- Different stepping stones consisting principally of low shrubs. The stepping stones form part of the local ecological corridor between East and West of Wageningen campus.
- The Dassenbos on the east side of the campus where nature is left undisturbed.
- Long avenues with trees along the main roads that give a linear green structure to the campus.
- Large ponds where surface water is collected. The ponds are part of the ecological water structure of Wageningen city and have shallow banks for amphibia.
- Ecological garden around Lumen building.
- Sustainable water management to clean the water.

The Wageningen UR campus has a highest average ground water level of less than 0.4 metres below ground level, and a lowest average ground water level between 0.8 and 1.2 metres below ground level. This means that the campus is located on soils with the groundwater table III. The direction of flow ranges from west-south-west in shallow ground water, to more southward in deeper ground water [1]. The texture of the soil is loamy fine sand with on the north side of the area a metre of thick sand. Deeper in the soil, there is a humus and a peat layer [1]. Additionally, the soil has been disturbed a lot because of the construction of buildings, so the texture in the top layers is changing constantly (personal communication Andre van Amstel).

The Campus is composed of 14 buildings with different architecture styles, namely: Lumen, Actio, Atlas, Axis, Droevendaal, Forum, Futurum, Gaia, Leeuwenborch, Orion, Radix, Vitae, Zodiac and the Bongerd Sports Centre. Figure 2, shows the two most prominent student buildings on the main campus area.

Figure 2. Buildings of Forum (left) and Orion (right) on the WUR campus

Inventarisation before Atlas and Forum

Before the start of the construction of the Atlas and Forum building an Ecological Risk Assessment Study was performed in 2004 by Alterra, a research institute on the campus specialized in the green living environment [11]. In this document there are a couple of inventories from different organisation about the flora and fauna present in the area where the new building would be located and also the effect of the new projects and plans on the flora and fauna.

In the next pages we will describe the most important findings in this study. The complete list of animals and plants can be found in Appendix 1.

Mammals

Regarding mammals, one of the most important and most discussed group were the bats. In the Netherlands all bat species are in the category for highest priority of protection according to the Flora and Fauna law (Ff-law).

This law became effective in 2002 and was created in order to protect species found in the wild, establishment of protected habitats, possibilities for management and decreasing the amount of damage to natural environments. The Ff-law has listed three levels of protection and the species that get this protection are listed in the corresponding table.

- Table 1. Common protected species. These species are protected against projects done by private people, these people have to get a building-exemption to continue their project. No building-exemption is required for spatial interventions by the government in the presence of these species, if the negative effects on these species because of a project are minimised. An example of such a project is the new bus lane across the Wageningen campus, which will be discussed in a later section of this chapter [12].
- Table 2. More strictly protected species. Building-exemption has to be given when these species are present, except when a project is executed by a governmental body according to a code of behaviour approved of by the minister of Agriculture, Nature and Food quality. The exemption will only be given if there are no negative effects for the species [12].
- Table 3. Very strictly protected species. If they are present, you always have to apply for a building-exemption, and it will only be granted if the project is very necessary, there is no other alternative, and there will be no negative effects for the species [12].
    - Table 3, appendix 1 or appendix IV. A building-exemption will only be given if the species will be able to continue to live locally, if there is no alternative for the project, and if the project is socially important. The last can mean: Protection of flora and fauna, public health or public security, or compelling reasons of public importance [13, 14].

Five bat species are present on the campus, and they are all located in Ff-law table 3:

- Nathusius' pipistrelle (*Pipistrellus nathusii*),
- Brown long-eared bat (*Plecotus auritus*),
- Daubenton's bat (*Myotis daubentonii*),
- Serotine bat (*Eptesicus serotinus*)
- Common noctule (*Nyctalus noctula*)

For these bats the campus functioned as a foraging area, for resting, reproduction and also as a corridor for some species.

For the other mammals, there is only a low quality inventory available for the area before the construction of the Atlas and Forum building. But also here the campus functioned as a foraging area, resting area, reproduction area and as corridor for these mammals. All the mammals have the lowest protection status, they are located in the table 1 of the flora and fauna law, except for the Eurasian red squirrel (*Sciurus vulgaris*), which is in table 2 of the Ff law. It is protected in most of Europe because its population has decreased continuously since the introduction of the eastern grey squirrel from North America, and because of the loss and fragmentation of its native woodland habitat [15].

Birds

The birds are the biggest group of animals observed on campus. This is not very surprising because there are also the most visible. All the indigenous bird species from the Netherlands are protected in the Ff-law table 2.

The most important findings regarding birds in this inventory were:

- The European Green Woodpecker (*Picus viridis*)
- The Barn Owl (*Tyto alba*)

These species are stated as vulnerable on the Red list of the Netherlands [16]. The Red list includes animals or plant species that are rare and are declining in number in various places. The list is made under commission of the Ministry of Nature. Because the Red list does not have a legal status, these threatened species are included in the Ff-law. The Red lists helps when establishing which species need to be protected [16]. The birds use the campus for different reasons like nesting area, foraging area, resting area and as a corridor.

Amphibia and fish

All the amphibia which were found in the ditches between the fields are on the Red list of the Netherlands. Furthermore, they are also protected by the Ff-law as stated in table one, see Appendix 1. Concerning fish, only one species was found on the campus, the ninespine stickleback (*Pungitius pungitius*) one of the most common fish in the Netherlands.

Insects

Regarding insects, four species of butterflies were stated. Three of these species are on the red list:

- Brown Argus (*Aricia agestis*),
- Old World Swallowtail (*Papilio machaon*)
- Brown Hairstreak (*Thecla betulae*),

The one species which is not on the Red list, the Mourning Cloak (*Nymphalis antiopa*) is the only one protected by the Flora and Fauna law (table 3). The others are not indigenous for the Netherlands. Non-indigenous species are only protected in that it is illegal to import them into the country, and for the stricter protected species there is a possession prohibition [17].

Plants

For plant species there was only a small inventory performed next to the Bornsesteeg. There were some species found which are protected by Flora and Fauna law as stated in table 1:

- Broad-leaved Helleborine (*Epipactis helleborine*),
- Marsh marigold (*Caltha palustris*),
- Grass lily (*Ornithogalum umbellatum*),
- Harebell (*Campanula rotundifolia*),

- Fuller's teasel (*Dipsacus fullonum*)
- Lesser periwinkle (*Vinca minor*)

Inventarisation after building Atlas and Forum

Subsequently, after the construction of the Atlas and Forum building another inventory was performed in 2009 [9]. If we compare these two inventories we can already get some insights in the effect of the new campus.
For the whole list of species found in the 2009 inventory, see Appendix 2.

Mammals

If we look at the bats species there is one species extra, Common pipistrelle (*Pipistrellus pipistrellus*), but this specie has only been seen once. The rest of the species are still present on the campus.
For the rest of the mammals in 2009 there was only looked for the bigger mammals. Two big difference were Roe deer (*Capreolus capreolus*), which were sighted near the Dassenbos, but nowadays there is an experimental area blocking the campus connection to the fields behind it. The second difference was that there was no Eurasian red squirrel (*Sciurus vulgaris*) sighted, although the area is very suitable for them.

Birds

For the birds, the European Green Woodpecker (*Picus viridis*) is still present at the border of the campus but the Barn Owl (*Tyto alba*) has not been seen during the multiple inventories. However, a new species of owl, the Tawny owl (*Strix aluco),* has been seen flying once between Atlas and Forum.
After the construction of the ponds a species of swallows *(Hirundinidae)* was found and is still present to forage on the insects above the water. A nesting area for the Common kestrel (*Falco tinnunculus*) has been installed on the top of the forum building, but until now it is not used as nesting area. For the common birds no inventory is present from 2009.

Amphibia and fish

There were no differences with the inventory of 2004 in regard to the amphibia. However, there are 3 more fish species present:

- the Three-spined stickleback (*Gasterosteus aculeatus*),
- the Common carp (*Cyprinus carpio)*
- Prussian carp (*Carassius gibelio)*

The last two species were probably put here by humans, but the three-spined stickleback may have migrated to the campus waters by itself.

Insects

The composition of butterfly species has completely changed, none of the butterflies stated in the Alterra inventory was found in 2009. One reason for this can be that the Alterra inventory 2004 was based on the findings of special species like Red list species or species which were protected over a longer period of time, while the inventory of 2009 was based on the sightings in a particular period.
The most important species of 2009 was the Large Skipper (*Ochlodes sylvanus*) which is on the Red list but not protected by the Ff-law. There is also an inventory for the Odonata available from 2009. But none of them are on the Red list or protected by the Ff-law.

Plants

And at last the plants species, in 2009 there was only looked for species which are on the Red list or protected. Lumen garden was not taken into account. The species found were:

- Epipactis helleborine (*Epipactis helleborine)*
- Rampion bellflower (*Campanula rapunculus)*
- Creeping bellflower (*Campanula rapunculoides)*

They are all highly protected species, but the last two species were found abundantly around the old plant science building, so there is a high probability that they were planted. In that case they are not protected.

Comparison between the two inventories

Summarising, there is not a very big different between these two inventories. It is very difficult to compare them because they were not done with the same methodology for the inventory of which species are present. We can say that there are no big differences in the composition of the bat community. For the other mammals, no big differences were found: one new species, the Roe deer, was seen and the Eurasian red squirrel was not seen anymore. Regarding birds, the Tawny owl was seen once between the Atlas and Forum buildings and after the construction of the pond, swallows were seen. There was no difference between amphibia sighted, but three new fish species were present in 2009. We cannot compare the different composition of the butterflies between 2004 and 2009 because the methodology for the inventarisation used was completely different.

For the plant species in 2004 the inventory was small and only took into account a part near Bornsesteeg while the inventory done in 2009 only described three plant species that were in the Red list of the Netherlands, so is also not possible to compare these finding.

Figure 3. Buildings Atlas (left) and Orion (right) on the WUR campus, seen from the WUR balcony

Surrounding areas of the WUR campus

Some of the goals of the campus are to strengthen the landscape structure, and to strengthen the overall quality of nature [1]. These goals can most easily be achieved by integrating the campus in the surrounding area. Therefore, this section is dedicated to describing the surrounding areas of the Wageningen UR campus, and making a comparison of species present on campus and in surrounding areas.

The WUR campus lies in the Gelderse vallei, between two large natural areas relatively close by: the Utrechtse Heuvelrug and the Veluwe. A better connection of these areas is beneficial to animals living there. The connection between these areas can be improved, by implementing a green corridor on the campus. To get a functional green corridor, its natural elements must be comparable to the surrounding areas of the campus. The stepping stones which form the corridor on the campus are only useful if they form a suitable environment to animal species in the surrounding areas. Another reason to look more closely at the surrounding areas is very simple; to know if the WUR campus's image fits in the environment.
There are many natural areas surrounding the WUR campus and Wageningen. It is important to know which animal species live there that could use the campus as a corridor or even as their home ground. Therefore it is also important to know what type of habitat is present in these areas and which species make use of this habitat. Also, for the campus to blend in more naturally with its surrounding landscape, it is vital to look at what natural ecosystem variety is found in the surroundings. The following areas are situated near or around the WUR campus and could have an influence on the campus wildlife:

***North of the campus*:** here lies the Binnenveld, containing the valley channel the Grift. This area is mainly composed of farmland fields and grass field vegetation interspersed with more natural borders of reed and ditches with wild Dutch vegetation. Many farmland birds can be found here. Further north two Natura2000 protected areas are situated: the Bennekomse Meent and the Blauwe Hel. According to the Natura2000 and the KNNV, both these areas have rare habitat types consisting of blue grassland (H6410), chalk marshes (H7230) and transition peatbog (H7140A) [18-22]. Thus, these areas might contain other animals, such as endangered bird species. However, since they are situated southeast of Veenendaal, these areas might be too far north of the campus [9]. Therefore, they are probably not taken into account by the WUR campus facilities department.

***West*:** here lies another part of the Binnenveld; named the Nude. The Grift also flows from here into the rest of the Binnenveld. Further away is the Grebbeberg, which is part of the Utrechtse Heuvelrug. Both the Grift and the Grebbeberg have a high natural value with many rare plant and animal species.

***South*:** the river forelands (uiterwaarden) south of Wageningen, called the Bovenste polder, consist of a large wet natural environment along the Nederrijn. This area is of great importance for the wildlife in the region and contains many different wetland birds and other animals that could, in theory, use the wet areas of the Campus as their home ground or as a corridor. Also, more to the west just below the Grebbeberg there is a natural riverbank reserve called the Blauwe Kamer. However, the fauna of the Grebbeberg and Blauwe Kamer might not have a large contribution to the

species that are present on the WUR campus, because both areas are situated around 4.5km from the campus.

***East*:** situated here is Wageningen-Hoog and Oranje Naussau's oord with its surrounding forests, both lie partly on the Wageningse berg and they are part of the south-western area of de Veluwe. These forest areas are home to many birds, squirrels and other small mammals, but also small heathland can be found with sandlizards. Further to the east lies the Renkums and Heelsums Beekdal, which is a very diverse and important natural area, characterized by wet grassland vegetation, brooks and creeks.

Surrounding area of Binnenveld

Just North of the WUR campus in the Binnenveld, there is a project in development to form an ecological connection zone, or EVZ (Ecologische Verbindings Zone) for animals between the East of Wageningen and the Grift West of Wageningen [2]. In total 65% of the landowners has already agreed to help. One of the possibilities for this zone is to use the borders of farmer's fields and those of the WUR test fields as a part of the EVZ. An example of possible changes is an increase in border vegetation of these fields. That would be necessary to increase the amount of food and shelter for animals, hereby improving the ecological corridor functioning of both the EVZ and the WUR test fields. The main idea behind the EVZ is, that it will be used by many animal species to transfer from the forests in the east of Wageningen (which is part of the Veluwe) through the Binnenveld area, towards the Grift and then to the Utrechtse Heuvelrug and vice versa. The EVZ thus completes the corridor from the Veluwe to the Utrechtse heuvelrug, through the Gelderse vallei [2].

The zones will mainly consist of natural vegetation which already exists, or fits in the landscape. Also some shrubs and trees will be planted, like Willow, Alder and Common Hazel. These will form stepping stones in which animals can rest. The final design will increase the functioning of this ecological network by using these bushes, but will also include wild flowerbeds next to fields, reedgrass and shallow sloping banks along ditches and water borders. The zones will be around 4 meters wide to accommodate passage of badgers and other mammals. If the project also wants to focus on making the corridor more suitable for grassland birds and birds of prey, the natural borders should be between 9-12 m wide. However, it is not yet certain if this will be the case [2].

Vegetation present in the Binnenveld consists of a wide variety of species. Among others, Ragged robin (*Lychnis flos-cuculi*), Water-crowfoot (*Ranunculus aquatilis*) and Bulrush (*Typha latifolia*) can be found. But, also more rare flora can be found in the bluegrasslands, like *Carex* and orchid species [23].
The EVZ project has also done some research on animal species in the area, it has found that the EVZ would especially be of use to the European Badger (*Meles meles*) and European pine marten (*Martes martes*) [2]. Indeed, some badger tunnels have already been made. Figure 4 shows a map with the situation of the EVZ as it is planned now in the Binnenveld, with the WUR campus and test fields.

Figure 4. Adaptation of the map [2] of the upcoming EVZ. In the Binnenveld, it will be situated in the east of the WUR campus, the north and in the west. For a more detailed look, zoom in on the map.

Altogether, a large variety of fauna can be found in the Binnenveld. Many meadow and farmland birds live here; species such as the Eurasian Oystercatcher (*Haematopus ostralegus*), Northern Lapwing (*Vanellus vanellus*) and Black-tailed Godwit (*Limosa limosa*). More rarely seen are also the Eurasian Curlew (*Numenius arquata*), Common Redshank (*Tringa totanus*) and Common Kingfisher (*Alcedo atthis*). Among farms in the Binnenveld, the White Stork (*Ciconia ciconia*), Barn swallow (*Hirundo rustica*) and the endangered Little Owl (*Athene noctua*) can be seen nesting.

Also different fish and amphibia, such as the smooth newt (*Lissotriton vulgaris*) live here in brooks and ditches. Some of the mammals that use this area are: different bat species, the Eurasian red squirrel (*Sciurus vulgaris*), European badger and the rare and endangered Eurasian water shrew (*Neomys fodiens*) and European pine marten [2, 23-25].

Other animals living in Veluwe area could also use the EVZ as a corridor to the Grift area or Utrechtse Heuvelrug. This corridor function, would then also apply to the changed borders of test fields of the WUR. Furthermore, the possible animals that use the EVZ might eventually use parts of the WUR Campus as their corridor as well. For example the stepping stones can be used, if these prove to be a suitable environment.

In the southern part of the Binnenveld there is a connection with the Grebbeberg at the Nude and the Grift. Here are also many reptiles such as the grass snake (*Natrix natrix*), viviparous lizard (*Zootoca vivipara*), slowworm (A*nguis fragilis*) and endangered amphibia such as the northern crested newt (*Triturus cristatus*) [25]. Amphibian species, but also grass snakes stay close to the water system in this area. The water system of the Grift is connected to the one in Wageningen, which in turn is connected to the one from the WUR campus. Therefore these water areas of the Binneveld are important to keep in mind, since species from the Grift could migrate all the way to the Wageningen UR campus.

The Uiterwaarden (the Bovenste Polder and the Blauwe Kamer)

A large natural river area runs south of Wageningen, called the Bovenste polder. It is part of the Uiterwaarden and is connected to the ditches, ponds and other waterways of the Wageningen municipality and WUR campus. In this area many amphibia are found such as the natterjack toad (*Epidalea calamita*) and northern crested newt, which are both rare and protected. Since 1994 the grass snake lives here as well. Probably it profited from the increased natural development of the area and increased swamp area [26]. However, no recent research or inventories of amphibia or reptiles has been done. Also no research has yet been done on fish species in the area, but many different species have been seen by amateur fishermen. Mammals also live in the area and frequently European rabbits (*Oryctolagus cuniculus)*, hares (*Oryctolagus cuniculus)*, red foxes (*Vulpes vulpes*), red squirrels, European moles (*Talpa europaea),* European hedgehogs (*Erinaceus europaeus)* and several different bat species are seen. Not many other sightings of peculiar mammals have been seen in the area, apart from the rare sightings of the Eurasian beaver (*Castor fiber)*, which is a very rare resident, living in the nearby area of the Blauwe Kamer [26, 27]. In the area of the Grebbeberg and the Blauwe Kamer also many other mammals can be found that do not occur in the Bovenste polder, for example weasels such as the short-tailed weasel (*Mustela erminea*), the least weasel (*Mustela nivalis*) and the European polecat (*Mustela putorius*). Also many small rodents; mouse, vole, shrew, rat and endangered bat species live in the area. Finally, also the rare European pine marten lives here [27]. Because it is also found in the forests of the Veluwe East of Wageningen, a favourable corridor for this animal might be a broader forest rich zone through the Uiterwaarden on the South of Wageningen. The EVZ north of the WUR campus might be a less favourable corridor route for this animal [2]. Apart from mammals, fish and amphibia, many birds and insect species are present here. A summary of bird, dragonfly and butterfly species can be seen respectively in appendix 3, 4 and 5 [26].

Forests near Wageningen (Wageningen Hoog, Oranje Naussau's Oord & Wageningse berg)

The available information on the natural conditions and animal species present on the East of Wageningen is limited. However, an organization that wants to keep the Dreijen (old part of the WUR Campus) intact, did an inventory on bird, butterfly and dragonfly species that were present here [28]. These species also come from nearby regions. An overview of all these species is summarized appendix 6 and 7.

Flora and Fauna on the WUR campus

A comparison can be made between species in the surrounding areas and species already seen on the WUR campus. Animals from environments with a wide range of abiotic factors already come to the campus. Close to 80% of the animals sighted in the 2004 and 2009 inventories of the Wageningen campus have also been sighted in the surrounding areas, and vice versa, a large proportion of the animals reported to live in the surrounding areas has been sighted on the campus. This is a sign that the campus is used as part of the natural landscape. However, the campus can be integrated even better in the surrounding areas if the accessibility of the campus for animals increases. This accessibility can be increased by implementing a green corridor across the campus, which could be used by, for instance, mammals, birds and insects.

Ecological Corridor on campus

In the twentieth century, much of the Dutch nature disappeared. The remaining areas are often small and far apart. The Dutch government wanted to link patches of nature into a connected framework of natural areas with connections between them in order to allow migration of organisms between these natural areas. The theory behind this ecological network is mainly based on the island theory of MacArthur and Wilson [29]. According to this theory, the number of species found on an undisturbed island is determined by immigration and extinction, which are in turn affected by the distance of the islands from other sources of colonies and the size of the island. By connecting nature areas in a land which is intensively used by humans by the means of ecological (or green-) corridors, the government hoped to create one big 'nature-island' in the middle of human occupation, thereby reducing extinction on this 'island'. This project is called the Ecologische HoofdStructuur (EHS, ecological main structure), and one branch of this structure is situated north of the Wageningen Campus. The National plan includes two ecological corridor between the natural areas of the Veluwe and Utrechtse Heuvelrug and one of them passes over Wageningen Campus [1]. For this reason the campus should contain a natural corridor that animals can use. This ecological corridor is still partially under construction and because of the new building plans, some of the components of the corridor have been removed or relocated.

The components of the corridor which will run across the Wageningen campus are stepping stones. Stepping stones are relatively small areas of nature, which animals can use when moving from one area to another. The original plan was to have seven stepping stones on the WUR campus consisting mainly of low shrubs (see the green dots is Figure 4) [30]. However at this moment it is only possible to recognize three stepping stones, one south of the Forum, one east and one south-east of the Atlas. To connect the different stepping stones, Busman (2013) recommended to have strips of grassland and to manage them as hay, which is to mow them in Autumn [30]. Also higher grass vegetation would have been added, that could be mowed twice a year. This extensive plan was made this way, so that different kind of insects and small mammals would be able to pass from one stepping stone to another. One of the stepping stones (south-east of Atlas) is not surviving very well, which is probably partly due to the fact that the soil is too wet, which can cause oxygen deficiency in the plant roots [30].
The other part of the ecological corridor is located along the avenue Bornsesteeg and Dijkgraaf and is mainly composed of trees. An ecological garden is also located behind the Lumen building, which can provide a good connection to the surrounding areas and the ecological corridor north of the WUR campus [1].

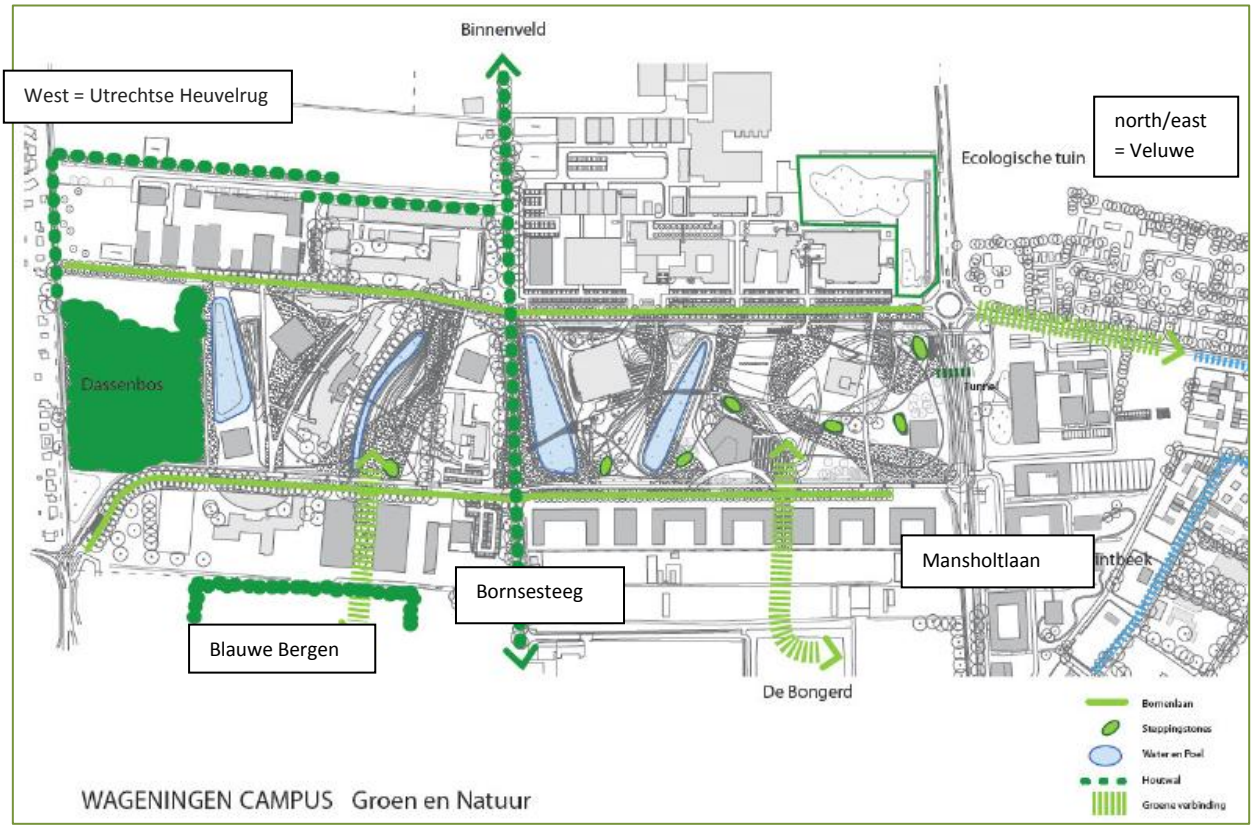


Figure 5. **Map of green areas at Wageningen campus. (Adapted from [1])**

The following green structures can be recognized on the map (see Figure 5), that are part of the Ecological corridor:

- A wooded bank along Bornsesteeg which forms an important link with the Binnenveld and the northern part of the ecological corridor.
- On the south side of the campus, a green connection with the Blauwe Bergen.
- The connection areas inside the ecological corridor are designed through multiple corridors (ribbons) and stepping stones (landscape element and natural Islands).

Because of obstacles in the area, (such as buildings and the Mansholtlaan) the regional ecological corridor has to follow an alternative way from north to south. The north part of the WUR campus is not included in the ecological corridor, while the south part of the corridor runs approximately along the Bornsesteeg, Droevendaalsesteeg and NIOO building and reaches the Grintweg. The north part of the Ecological Network is part of the ecological connection at the regional level, while the south is part is the ecological connection at the city level and it is supposed to connect the campus with the city of Wageningen.

The EHS was officially introduced in the Nature Policy and was later included in the Structuurschema Groene Ruimte (SGR, Green Space Structure Plan). Therefore, any intervention that can affect the EHS is not allowed, unless other interests justify the intervention. Furthermore, in the case of intervention, compensating measures have to be taken [12].

Future situation

To determine what projects on campus could be necessary and desirable, an overview of not only the current situation is needed, but also an overview of the future plans. In this chapter, we describe the projects which will most likely be executed within the next 5 years, and what effects these projects might have on the natural diversity of the campus. The projects that will be discussed in this chapter are the future bus lane across the campus and the Campus Plaza, but also the Eetbare Academische Tuin (EAT) project and the plants that are scheduled to be planted within the next 5 years.
Obtaining information was very difficult for several of the projects which are scheduled. For the Helix building (under construction), only the most general information could be found in the "beleidsplan" of 2009. Also, there is no definite information about the Incubator and the High-Tech centre. For these, the only information one can obtain is extrapolating from information about the Campus Plaza. Therefore, these three areas are not included in this chapter.

Bus lane

The future bus lane is located on the Wageningen campus, and is far removed (at least 2 kilometres) from any protected nature area. Therefore, no direct or indirect harm will come to Natura 2000 areas, Natuurmonumenten areas or areas of the Ecologische Hoofdstructuur (EHS, ecological main structure) because of this bus lane [12]. However, the bus line does cross the open area between het Dassenbos and the Blauwe Bergen, which has been marked as an ecological corridor in the municipality's policy. This might be a problem for ground-dwelling small mammals [12].
The bus lane might affect species protected by the Flora- and fauna law (Flora en fauna wet, Ff-law).
The most recent documents which give an overview of the species present on the Wageningen UR campus were published in 2009 [9]. We are aware that many changes may have occurred in the years between the writing of those reports and the present, but since there are no more recent documents, we will base our analysis on these documents.
As can be seen in Appendix 8, quite some protected species have been seen in the area of the future bus line, or are expected to appear in this area. For the most part, these species have a Ff-law table 1 classification. No building-exemption has to be given for these species, since the bus line is a project of spatial intervention. No specific plan for dealing with these species has to be made. There is one species with Ff-law table 2 classification. This plant was found around building 119, which has been used by the Plant Science group of the WUR. The history of the building and the excessive numbers of individuals found, indicate this plant was sowed there. Plants that have been sowed by humans are not considered to be part of nature, and therefore do not influence the future project of the bus lane [12].
There are 6 mammal species with Ff-law table 3 classification on campus. These are all bats. The trees which grow next to the Bornsesteeg provide an important connection route for the bats. The amount of trees cut down to provide space for the bus line must be kept to a minimum, and prior to cutting them down, their function for the bats must be re-evaluated. If the trees are used by bats, or if they serve as a nesting place for birds, an exemption has to be requested.
Non-specific effects of the bus lane may include light pollution of nature areas, sound pollution of nature areas, destruction of habitat and disruption of the connection between two nature areas (Dassenbos and Blauwe Bergen) [12].
Light pollution is estimated to have the largest effects in the areas of the Bornsesteeg, and close to the Dassenbos and Blauwe Bergen [12]. Light pollution could negatively affect behaviour of bats and

birds, as well as disturb the day and night cycle of both animals and plants present in the area [31-33].
Increased intensity of traffic due to a new bus line can increase the sound pollution that filters into natural areas. Research shows sound can affect animals' behaviour, reproductive success, population density and community structure. The boundary at which these effects can start lies between 55 and 60 dB(A) [34]. In the "Quickscan flora en fauna busbaan Wageningen", Grontmij Nederland B.V. has provided a map on which the 42 dB(A) boundary of sound produced by the new bus line is depicted (see Figure 6 [12]). This shows that a small portion of the Dassenbos is within the 42 dB(A) area of the bus line. It is logical to assume that the 55 dB(A) contour of the new bus line, in which animals may start to suffer from the sound, is smaller than the 42 dB(A) contour. Therefore, the area of the Dassenbos which suffers from sound pollution will be very small. Although no sound-contour could be found, the row of trees along the Bornsesteeg, which are important for bats, can logically be expected to experience an increase in sound. As sound grows stronger closer to the source, the trees located immediately next to the road may experience too much sound.
The future bus line is located in between the nature areas of the Dassenbos and the Blauwe Bergen. The increased amount of traffic may have a negative effect on the movement of small mammals between the Dassenbos and the Blauwe Bergen [12].

Figure 6. Map of the new bus line near to the Dassenbos, with 42 dB(A) contour in yellow.

Campus plaza

The Campus Plaza is another project which will probably be executed within the next 5 years. A research is being done about the effects of Campus Plaza on ecological and other aspects of the area, but this research has not yet been completed. Therefore, the information presented in this paragraph is based on older data.

The goals of the campus plaza, as stated in the 'Campus Plaza, Nota van Randvoorwaarden en uitgangspunten', are [35]:

- To increase liveliness and social security of Wageningen UR campus.
- To increase the number of student rooms.
- To increase the commercial facilities at Wageningen UR campus.

- To help shape the Wageningen UR campus as meant by Jeanne Dekkers, author of 'Masterplan de Born", 2009.
- To help shape the function of the Bornsesteeg as entry point to the Wageningen UR campus (mainly for slow traffic).

The plans describe a Campus Plaza consisting of a maximum gross floor area (gfa) of 17.200 m^2, including max. 1.200 m^2 gfa commercial, max. 1.000 m^2 gfa children day-care, and max 15.000 m^2 gfa living area. The students rooms consist of approximately 150 independent rooms, approximately 200 rooms with shared facilities and a maximum of 50 short-stay rooms.
The maximum building height is 22 meters, and maximum building height along the Bornsesteeg is 15 meters [35].
Another requirement is that the adult specimen of Sequoia on the west side of the building area must be integrated in the design and protected during the construction.
The traffic expected around the campus plaza consists mainly of bikes and public transportation users. A lot of pedestrians are expected around the future site of bus-stop "Bornsesteeg" [35].
The existing information on the area of the future Campus Plaza names one way in which the area is important for wildlife. The terrain of the future campus plaza is infrequently used as a foraging area by the common pipistrelle [36]. Building on the area decreases the use of it for the common pipistrelle, since the loss of vegetation means a loss of host plants for insects. Also, the added light-pollution may disturb the present bats in their behaviour.
The area may be inhabited by other animals, such as small mammals and insects, and it may be a foraging place for birds. However, no information was found about the presence of these species.

EAT project

The Eetbare Academische Tuin (EAT) project was the brain-child of two Wageningen students, and is being continued by students of various disciplines [37]. The project aims to create an edible academic garden to the east of Orion. It will convey the message that a multifunctional land use can help to create:

- a more attractive campus.
- more efficient use of land and services.
- connection between diverse groups and disciplines.
- demonstrate how a campus can play role in increasing quality of life.

The ideas for this garden include (see Figure 7):

- an amphitheatre for outside lectures or as a social meeting area.
- Sitting places, delineated by fruit-trees or other plants.
- Ponds for water storage, water treatment, and relaxation.
- Areas of bee-supporting plants.

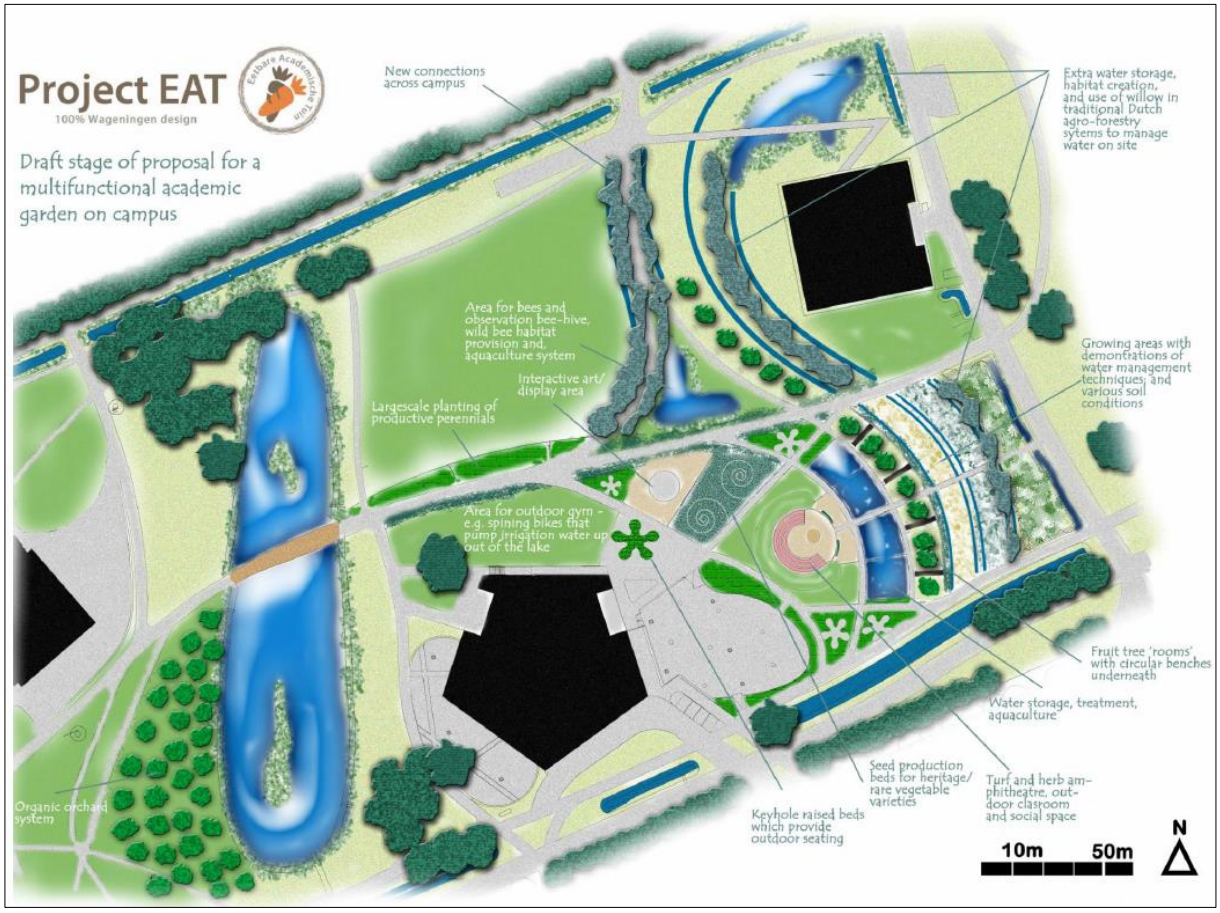


Figure 7. Draft design of multifunctional academic garden from EAT project (personal communication Elike Wijnheijmer)

The EAT project design is still in the developmental stage. Plans for an academic garden are not finalised yet, but if they will be executed in the way it is designed now, they will increase the number and the variety of species on campus. The garden will provide shelter for small animals, and food for insects and birds, and be a home for a large variety of plants. The design of the EAT project still has to be approved by the Wageningen UR board.

Plants and stepping stones

At this very moment, trees and plants are planted all across the campus, according to the design of Elike Wijnheijmer, facilities manager of Wageningen UR. A total of at least 51 trees distributed over 21 species (not including the trees which will replace the existing trees next to the Bronland) will be planted across the campus around Atlas, Orion and Forum in the near future. These trees range from crab apples (*Malus*) (height approximately 6 metres) to, for instance, Shellbark hickory (*Carya laciniosa*) (height approximately 25 metres). For a complete list of the new species, see Appendix 9. For a map of the campus with the new trees see Appendix 10.

New plants will also be planted around the Orion. Some 8500 individuals are planned to be planted, distributed over approximately 65 species and ranging in height from 25 centimetres to 25 metres (the trees planted near Orion are also listed in the previous paragraph). Most of these plants fall into the category of lower than 1 metre (approximately 5900 individuals, see Appendix 11).

The stepping stones which will make up the green corridor, as described in the chapter “Ecological corridor”, also have been planned. Four entirely new stepping stones have yet to be realised (for a detailed description of three of those, see Appendix 12). The stepping stones will consist of a variety of plants, which are attractive to either insects, birds or mammals as food resources, and which can provide cover for these animals.

Stakeholder analysis

In this section, the opinion of various stakeholders in the campus will be presented. We have identified the following stakeholders: students and employees of the WUR, the head and facility management of Wageningen University and Research Centre itself, Wageningen municipality, NIOO-KNAW, Hogeschool STOAS-Vilentum and Friesland Campina Innovation centre Wageningen.
We have gained insight in the opinions of Wageningen University and Research Centre, Wageningen municipality and NIOO/KNAW by contacting one or two spokespersons per stakeholder and asking them some questions. We are aware that this is not the most accurate method, but it was the only method we could use in the time we had.
The opinion of the campus users was gained from two surveys that have been conducted amongst students and employees of the Wageningen UR.
Hogeschool STOAS|Vilentum and FrieslandCampina Innovation Centre Wageningen were unable or unwilling to respond to multiple attempts to gain their opinion. Therefore, their opinion will not be taken into account in this report.

Campus users

When designing a location it is very important to take into account the opinions of the people who will ultimately use the location that is being designed [38]. Therefore, we have selected the 'Wageningen UR campus users' as one of the stakeholders in the Wageningen campus. As for all stakeholders, we have tried to determine the wishes of the campus users as well as possible.
In this case, we have done this by studying surveys that have been performed to get to know the opinion of the student and staff about the Wageningen campus's landscape design. A summary of the results of these surveys will be given below.
Two surveys were conducted to know the opinions of Wageningen campus users. An online survey was conducted between 16-09-2012 and 9-10-2012 by Bresser et al. [3] and another online survey was done around 2010 with the purpose to know the opinions of student in order to include them in a Landscape architecture thesis done by Sri Shindi Indira [38].
The first survey, which we will call the "campus survey", was done among 906 people. 55% of the responses were from students and 45% were staff, 714 of the responses were in Dutch and 192 in English. 40% belong to the domain of Living Environment and Environmental Sciences groups and the distribution of gender was 67% female and 33% male [3].
The second, "thesis survey", was conducted among non-landscape Architecture students who answered general questions about nature, natural environment and about the landscape of Wageningen campus. 63 questionnaires were completed, 46 responses were Dutch students (22 females and 24 males) and 17 were international students (6 females and 11 males). 47.7 % of them was between 21-25 years old and 62.7% was a master student [38].

Figure 8. Examples of the ideal landscape on campus and the proportion of people that prefer this landscape on the campus, Bresser et al. [3]

Survey results

The "campus survey" found that the campus has too many bare open areas, that it is boring, looks empty and is not attractive at all. They suggest that a variation in the vegetation might make the campus more attractive. In fact, the natural garden behind Lumen building was exemplified as an ideal design to make the campus more attractive. 54% of the respondents think that the campus is not as natural as they would like to see it. When they had to select what kind of landscape they would like to see on the campus, 63% answered a landscape as seen in Figure 8, bottom-left, with scattered trees and short grass under them. They also appreciate more open landscape with low vegetation and an orchard of trees (see Figure 8, top-right). What they clearly do not desire is the campus as uncovered grass (see Figure 8, top-left), or as dense forest (see Figure 8, bottom-right).

On the other hand, the "thesis survey" found that 61.9% of the respondents think that the current campus landscape is ok, while 4.7% did not like it at all. The difference in opinion between the two surveys is quite difficult to explain. A part of the explanation might be that the respondents of "campus survey" were people with a different study, or WUR staff, and thus a different perspective on the campus than the respondents of the "thesis" survey. Probably, the "campus survey" is more reliable because it has more replicates (906 people) than the "thesis survey" (63 people).

When the survey asked a follow up question, about own opinions regarding what should be included in the campus landscape, the "campus survey" shows that 87% of the respondents would like to see more trees, 85% more flowers, 55% more shrubs and 43% larger grass. They think that having more green spaces will make the campus more attractive to go to relax or study. Trees provide a sheltered spot and give some privacy, thus the site immediately looks friendlier. Also, some people suggest including more running water streams. However, they were satisfied with the amount of cycling paths and footpaths.

Additionally, there was a question regarding the opinion on how the campus can be best decorated and covered. 28% of the respondents would like to see a tree garden, 14% a fountain, 11% an open air theatre and 9% more animals, see Figure 9.

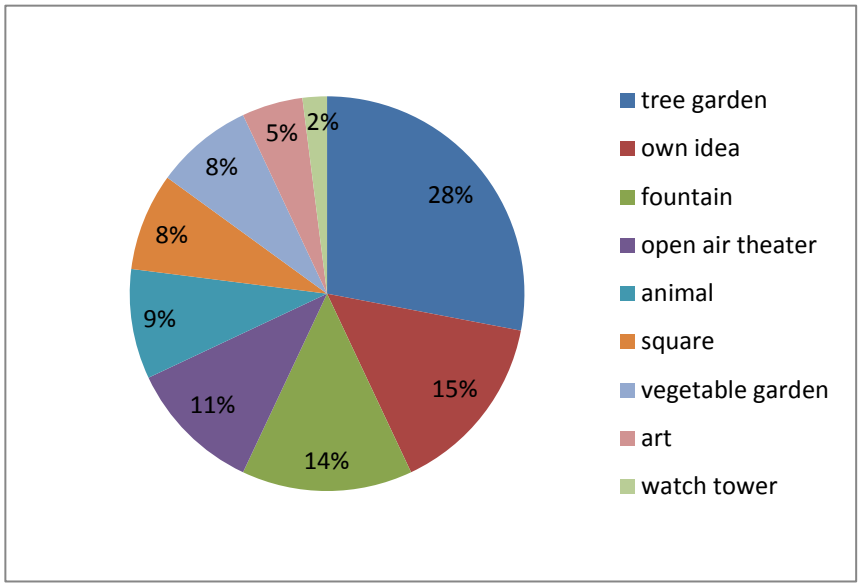


Figure 9. Respondents opinion (%) regarding what could be added to enhance natural beauty of Wageningen UR campus [3].

A small number of responses show that the student and staff like the situation of uncovered grass and think that nothing needs to be changed. So, some of the people have a rather positive impression about the campus, but nonetheless most people desire more diversity in vegetation with more trees and flowers.

In the thesis done by Sri Shindi Indira, she suggested, based on the responses of her survey, that the landscape of the campus should include: more trees to protect against wind, more rocks to sit on, larger grass fields, a small forest and a more natural and hilly landscape [38].

Regarding the facilities of the campus the “campus survey” show that the 36% of the respondents would like to have more seating facilities and picnic tables, for example along the water front, whereas 27% desired a supermarket, café or kindergarten. Only 7% wanted more parking places. Opinions vary significantly between employees and students. Employees mostly demand other facilities like a supermarket or nursery whereas most of the students want more seating spaces. In the comment box, which was included in the survey, some people desired extra bicycle parking spaces, a central space for meeting, a café or a bar with patio, stalls where food could be purchased or a basketball court. On the other hand, most of the respondents see the campus as impressive as an institute of international standard requires. But, one of the comments that was expressed in the survey literarily describe the campus as *"The campus currently provides such a desolate impression, with a violent wind flowing between the open colossal buildings"* [3].

Opinions regarding impressiveness vary between international and Dutch students. International students feel proud and are more impressed of the campus than the Dutch. They also mentioned the landscape and the facilities of the campus played a large role to finally choose Wageningen University for their studies. The appearance of the buildings is very variable judged, some people find that the style is too square, very impersonal and it reminds them a massive learning factory. Others have a very positive opinion about the majestic buildings, many people find that the combination of this great unique buildings and open terrain can define the campus as "impressive”. However, they

also think that it can be a kind of static and gives a cold impression and some think that they are not combined nicely with the outside. Forum building is consider as beautiful, pleasant, interesting and appropriate for Wageningen UR. On average, the respondents score the Wageningen campus as a whole with a 7.0. This is not bad, but it can be improved [3].
On the other hand, in the thesis done by Sri Shindi Indira, she suggested, based on the responses of her survey, that the facilities of the campus should include: a more open view between the buildings, a special walking route for temporary seclusion, a direct connection for bikes and pedestrians from the Forum to De Bongerd sport centre with a bridge over the small stream, and a fountain around the Forum landscape [38].
Summarising, the most of the people that answered the surveys would like to see more trees and more flowers on the Campus. In Wageningen University there are several groups in the field of landscaping and hydrology that could help to include the opinion of these surveys on practice.

Wageningen University and Research Centre

The WUR thinks we should not forget that a large part of the campus is listed in the bestemmingsplan as 'purpose land: education', and only a small part has the purpose of nature [1]. If you make a parkland out of the campus, it will inhibit the 'industrial' function of the campus. Also, new nature in some places might mean that future development of the campus will be delayed. Therefore, a park-like campus is not acceptable. The WUR would like to see an improved connection between various natural areas on the campus. Especially the bicycle path between De Bongerd and Orion has a lot of potential.
The WUR feels that the campus is split in two by the houtwal next to the Bornsesteeg. This division of the campus is undesirable, the WUR would like it better if the campus was one entity. They would like to see pieces of the houtwal being cut back a bit in some places, so there are more open views between the east side of the campus and the west side.
Also, the WUR would like to see the development of a nature area on the fallow terrain between Dijkgraaf and the bicycle path to the north (personal communication Ad van der Have and Elike Wijnheijmer).

Municipality

The Wageningen municipality is also a stakeholder in this project. It views the WUR as one of the most important economic aspects of the city. They feel that maintaining the status of Wageningen UR as leading university in its field is very important to keep this economic status. They see the Wageningen UR campus as a business cart for the WUR, and therefore as a business cart for Wageningen. They feel that an attractive campus can help entice students to come and study in Wageningen, with all the economic benefits.
The municipality would like to see a Wageningen campus that is more integrated in the surrounding landscape, both visually and functionally. They would like to see the campus ground look more alike with Wageningen-Hoog to the east, and het Binnenveld to the west. Functionally, the most important project they would like to see completed on the campus is the green corridor and its stepping stones. The municipality has provided some measures to accommodate animals to cross large roads, but they would like to see the corridor completed on the grounds of the WUR too.
Wageningen campus is the first sign that you see when you arrive in this city from Ede, thus making the campus even nicer will also enhance the image of Wageningen city as a whole (Personal communication with Michiel Uitdehaag, municipality Wageningen).

NIOO/KNAW

NIOO/KNAW would like to see more biodiversity at the Wageningen UR campus. They would like to see more species of native plants, and would like more bushes and hedgerows on the campus to accommodate smaller animals such as birds, insects, bats and other small mammals. They would like to see more flowers on the campus, instead of only grass.

They would also like to see a permaculture, a highly sustainable, long term agro-forest, on the Wageningen UR campus. One such area is now being implemented on the grounds of NIOO/KNAW, and they think it would be very nice to have such an area on the Wageningen campus.

The modular plans

The modular plan consists of separately executable plans to improve natural diversity at the Wageningen UR campus, and to protect the natural diversity of the campus from negative effects of future projects. The plans are derived from the ideas given to us by the stakeholders and from our own ideas. Although the plans can be executed separately, the plans do have some relation with each other. For example, the proposed insect garden can be very helpful for the survival of the green connections, because the flowers which are used in the green connections will need enough insects for a healthy reproduction. First, our vision for the whole campus will be explained and after that a description of each modular plan will be given.

Our vision:

Our vision is to have a more natural looking campus. We share this opinion with several of the identified stakeholders, such as other students and staff of the Wageningen UR, the Wageningen municipality and the NIOO/KNAW. In this way you also get more support and a better working-environment. Nowadays it looks like the design of the campus is more orientated towards the design of the buildings, rather than focussed on life sciences. We are a life sciences University, not a technical University and we feel that this should be reflected in our campus. This University should show to the world what it is doing and what it has accomplished in the past. Furthermore, this campus covers a big part of the north of Wageningen, so we think it should be incorporated more into the surrounding areas. Therefore our goals for the campus are:

- To improve the natural connection on the campus and from the campus to the surrounding areas.
- To provide a more natural environment for animals on campus.
- To improve the campus' looks and feeling, in the eyes of various stakeholders.

We have made four concepts for the campus in which these three main goals can be achieved:

- ***Park-like areas***
  We want to create a park like area to sit and relax in. This area should be more open and made mainly for the use of people. This area will be in the middle of the campus in between the Orion, Atlas and Forum building. There will be nice maintained flowers strips and trees providing shade.
- ***Natural (wild) areas***
  A part of the area of the campus should contain more natural areas. The main focusses of these areas are animals and plant species and their needs. These will be less maintained and wilder looking, like the Dassenbos, to create a better living environment for animals and plants.
- ***Integration of buildings with the green campus***
  The buildings on the campus are not really incorporated with the natural look of the campus. They are most of the time surrounded by empty parking lots. To create a more natural campus the building should be integrated more with the rest of the area.
- ***Use the campus for experiments/showcase***
  The Wageningen University is a life science university and they do a lot of research on nature. The campus can also function as an area to do experiments or to show new techniques that are invented. Different new techniques can be used to create or maintain natural areas. Experiments can be performed in these areas by different chair groups to gain knowledge on aspects of nature and its conservation.

Overview of modular plans:

To put these concepts into practices we came up with several ideas. We will present these ideas with the use of modular plans in the order from smaller to bigger projects, see the list below. In the plan first some small practices are discussed, to easily create a higher natural diversity on the campus with small scale, faster modules. Continuing the list, bigger projects are discussed, which covering larger areas of the campus or take more time to complete. This is not definitive, since the order does not really matter and is solely based on our ideas, however it is best that at least some distinction can be made in size/time and effort a plan might take. Figure 10 gives an overview of the campus map, with all the areas indicated as letters. These areas are often referred to in the in the plans and are shown in the list below.

Plans:	***specific area:***
• Light regime	No
• Sitting places, niches and moveable nature	B,D,E,F
• Meeting place / Amphitheatre	F
• Wooded bank	C,D
• Integration of buildings	No
○ Plantations near buildings	No
○ Climbing plants on buildings	No
○ Planting of trees on parking lots	No
○ Vegetation in stone hedges	B,D,E,F
• Artificial nesting sites	No
• Green connections	No
○ Blauwe Bergen-Dassenbos	A
○ East-west connection	D,E,F
○ Connection Campus -Bongerd	G,H
• Flower meadow strips	B,D,E
• Fruit garden	F
• Insect garden	F
• Ponds and wetland areas	F

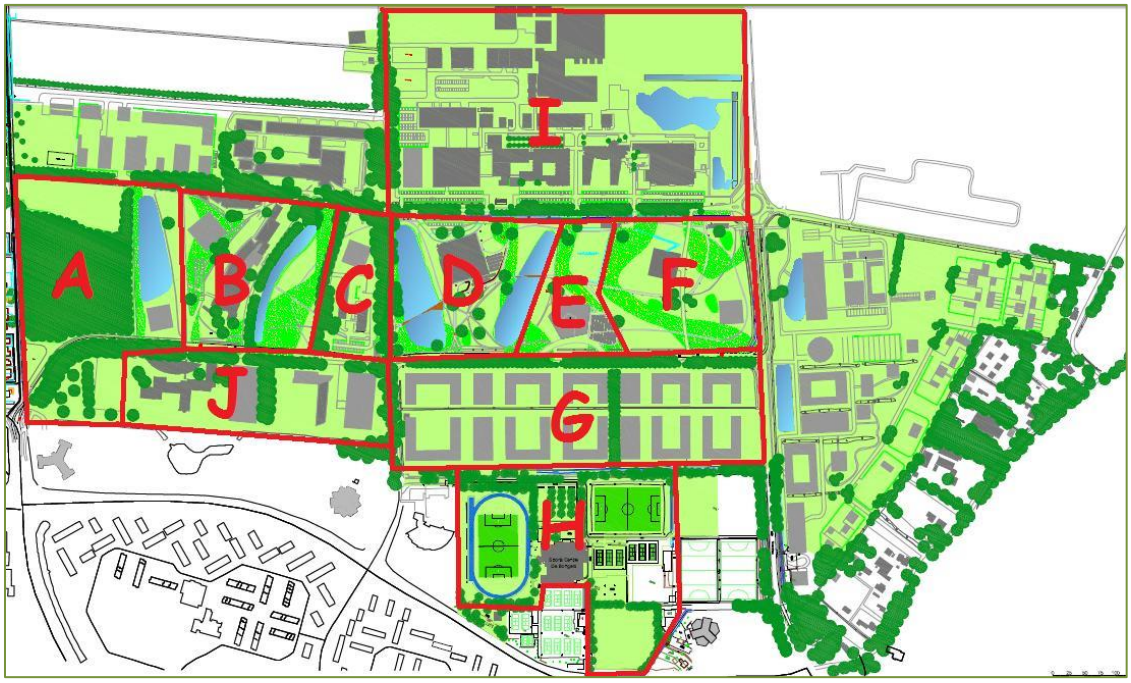


Figure 10. overview of areas, on the WUR campus in which different modules can be incorporated.

Light regime

There are plenty of articles reporting negative influences of light pollution on plants and animals. Light pollution at the campus can negatively influence night-time animals, by inhibiting their movements and changing their behaviour, or by disturbing their circadian rhythm (day-night cycles), making day-time animals think it is day while it's actually night [39]. Several measures can be taken to minimise the amount of light pollution on the Wageningen campus.

Nature friendly lighting

To minimise the negative effects of light pollution on the campus, animal-friendly lights could be chosen. In this case, animal-friendly lights means that animals can't perceive the colour of light emitted from the light source, or that the colour of light can be perceived, but does not change their behaviour.

The problem presents itself immediately: Not all animals can see the same range of colours, and colours that don't disturb one animal, may be very disturbing for another. This is the case with two groups of protected animals on the campus: Birds and bats [40].

Birds which fly on their internal compass at night can be disturbed in their navigation by strong, artificial light in the red spectrum. This causes them to lose track of direction. They can't see the green spectrum of light, so this has no effect on their navigation. Therefore green lighting is very bird-friendly [41]. However, other experiments show that bats are very much disturbed by white, blue and green artificial light at night. They won't fly near the light, and will choose another area over the lighted area to fly in. They are not disturbed by light in the yellow/red spectrum though [42, 43]. Therefore, yellow/red light is more bats friendly.

This is a clear conflict of interest. The eventual choice of the colour of streetlights should depend on a detailed analysis of which species use which areas, and adapt the colour of streetlights to the species that use that area.

Dimming of lights

The solution to the problem stated in the previous paragraph may lie in the intensity of the streetlights. Research has found that birds experience less disorientation from red light, if the light has a lower intensity (1 - 2 $mW*m^{-2}$) [44]. Therefore, the negative effect on birds may be cancelled if the intensity of the streetlights is low enough.

It is not plausible to decrease the intensity of streetlights over the entire campus. Especially at traffic junctions sufficient lighting is necessary to prevent accidents. However, at places where there is less traffic, or at least less junctions, and where there is a lot of nature, yellow/red streetlights with lower intensity might considered as an option to improve the quality of life for bats and birds alike.

Sitting places, niches and moveable nature

We want to have more sitting places around the forum. This is also suggested by a lot of people who took part in a survey did by a WUR MSc student [38]. But there is a lot of wind in the open areas [45]. Hence, this matter should be taken into account while creating more sitting places around the Forum building. This can be done by making some niches or wind shelters with the use of dense bushes in wind direction and low vegetation to make it nicer but still open. To make the campus more natural looking the sitting arrangement can be done as depicted below:

Figure 11. Shrub for more niche formation

Planting bushy shrubs for extra cover

Bushy shrubs, such as in figure 11, create niches where people can sit beside and be somewhat more covered from view. Such shrubs are also the preferable niches for insects, birds and small animals both in the time of snow falling and hot sun. Different plant species can be incorporated as bushy shrubs. It can act as habitat for insects and birds. If small sitting place can be arranged under bushy shrubs then it will be a good leisurely passing spot for visitors.

Figure 12. Benches surrounding tree base

Sitting places

Putting sitting benches around the basal portion of trees can create a nice sitting place and maximally utilizes the available space under trees (figure 12). It will also be efficient, because multiple people can sit there, without really having to know each other, facing opposite directions. Also, because you will be sitting under the natural canopy of the tree, there is some shade against summer sun and protection from rain during wet weather. Another idea is to create more sitting places in open, sunny areas which will help in providing niches during leisure time and also will also create places for visitors to get together. They are more out in the open and therefore nice to harvest sun rays during sunny weather. See figure 13 for an example of a natural created sitting space using only rocks.

Figure 13. Benches in open and sunny places

Also sitting places can be more sheltered from windy weather, by placing them near vegetation such as bushes and hedgerows. They can be modified for protection as shown in figure 14.

Extra picnic benches near water bodies could also be created, because there are still huge open spaces near the water on the campus. A lot of people who took part in a survey wanted more picnic benches on the campus [38], so that more people can also sit there during leisure time.

Figure 14. Windproof sitting space

Building rain shelters in open areas

Open hut like structures can be built in the open areas near buildings which can provide excellent shelter during snow fall and rain. It can also protect from strong winds if for example, two sides are made closed, see figure 15 for an Asian style reference.

These projects might be a good way to get students to join together on the campus more and create nicer sitting places. Landscape architect students could design sections of nature, even with simple designs, it might only take a handful of enthusiastic people to come up with these projects. It will be an easy way to make the central area of the campus more diverse and attractive.

Figure 15. Rainproof sitting shelter

Movable nature

Several areas of the Wageningen UR campus are used for events several times during the year. Examples of these areas are the event field and the area around the Forum. These vast open areas can be perceived as 'windy and desolate' [3]. To fill these areas with plants and structures to make them less 'desolate' would impair their function as area for an event drastically. This seems like an unsolvable dilemma, without a satisfying solution. However, these areas are not used for the largest part of the year. With a bit of extra effort before and after an event, these areas could be made more natural by the placement of 'movable nature'. Moveable nature would be, in this case, similar to plants in pots, only the pots would be more elaborate. Suggestions for moveable nature are, for example:

- A bench with plants attached, being several metres long. It could be surrounded at the side and the back by approximately 1.5 metre tall plants, which are planted in an integrated container with soil. See figure 16 for a sketch of this idea
- Moveable sections of wall (3-4 metres long and 2 metres high) with integrated containers, in which climbing plants are planted, as depicted in figure 16.
- Furthermore, art can be integrated with nature in such a way that it appeals to more people. Also some artists are in general approachable for such suggestions, so already existing art could be combined with plants, for a more natural look.

Figure 16. Top, Moveable bench with planted pots, Bottom, moveable planted wall

Meeting area / Amphitheatre

We propose to include an amphitheatre that would blend in with the environment on the campus and suggest several ideas to increase the natural diversity surrounding this area. The proposed location of the amphitheatre can be seen in figure 17. What is now largely missing according to many students is a common meeting place and more outside sitting places [3]. This amphitheatre could become the common meeting place for students and staff, and could increase the amount of sitting spaces, but furthermore it can be used for recreational and social activities, such as an open outdoor lecture, theatrical or musical performances and concerts, workshops and more. Therefore, more cultural aspects can be integrated on the campus and in addition, when people use it they will be able to enjoy the natural surroundings as well.

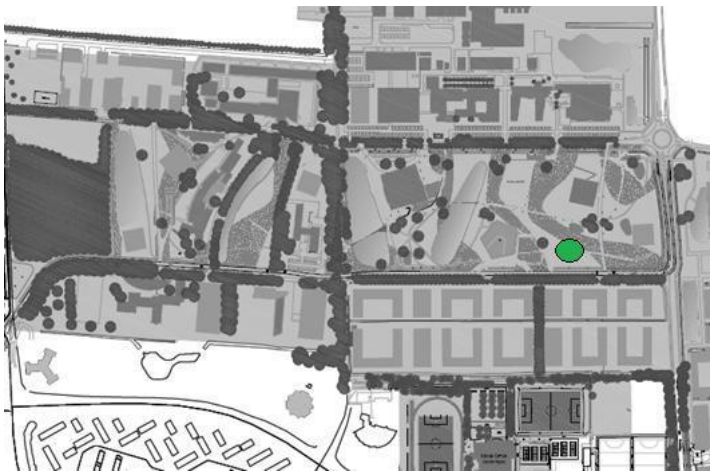


Figure 17. Campus map indicating the proposed location in green.

To build an amphitheatre on our campus it is important to take into account many different aspects such as the ground type, the materials that are going to be used for the construction, the structure's orientation, the architectonic acoustics, natural and artificial illumination, the ornamentation and vegetation in the surroundings and on the structure itself.

Since the soil-water condition of Wageningen campus is not optimal, we propose that the best option for making an amphitheatre would be to heighten the ground, rather than other ways of construction, such as lowering it and making a bowl in the ground, because this will probably flood in a short time. In this case, the amphitheatre will rise as an open hill from the ground with an empty middle area surrounded by places to sit. Another possibility is to build the amphitheatre with an outside or internal structure for stability, made out of; wood, stone or iron for instance.

In both cases, we would like to include plants in the surrounding area and on the highest place where the seats are located or on the bottom of the slope of the amphitheatre (for examples see the figures below). This would cause the top (and inside) of the amphitheatre to be sheltered from wind by plants such as the proposed fruit trees and shrubs (see fruit garden plan). The trees can also provide a kind of "ceiling" for the Amphitheatre and shadow in sunny days. The idea is to include the fruit trees within the same area as the amphitheatre.

The fruit trees might need to be placed on somewhat heightened parts of the campus, because many of the proposed fruit trees need a well-drained and deeper soil (see the fruit garden plan). They could also be placed on the structure of the Amphitheatre, which can provide an ideal soil condition for the fruit trees in order to provide them a deeper soil and lesser water conditions.

To find out what place would be best suited to the tree's requirements and to protect both the amphitheatre and wind vulnerable trees from the wind, it is important to know the direction of the wind. According to the four closest weather stations, the wind direction at Wageningen campus is mostly coming from the south-west [46]. Thus, the opening in the amphitheatre "hill" would have to be place in the direction with the least wind, opposite from this, which is in the north-east. There are already multiple examples of other university campuses that have their own amphitheatre and use it efficiently, some examples of amphitheatres are given below:

The campus is located on flat ground, the idea of creating a wooden structure of an amphitheatre might be a good suggestion. Figure 18, shows an amphitheatre which is located inside Afan Forest Park in Neath Port Talbot in Wales. It gives a nice example of what a wooden amphitheatre could look like.

An example of an amphitheatre located at George Fox University, Oregon, United States is show in figure 19. The university uses the amphitheatre for live shows, for listening to guest speakers, or even attending classes. As you can see in the figure trees surround the Amphitheatre and many sitting places are present. Also grass is growing on the sitting places, which might be a less good idea in the Netherlands because it would remain wet for a long period of time.

Figure 20 shows a part of the amphitheatre at the American University, Washington D.C., United States. In this university, they built an amphitheatre included in an arboretum. As can be seen, trees and plants are integrated in the landscape. The Amphitheatre provides a natural looking stadium with a stage for performances, lectures, and concerts.

The amphitheatre at Swarthmore College, Swarthmore, United States is home for concerts, dances, theatre, performance, weddings and parties. It includes Tulip trees (Liriodendron) and white oaks, which provide the ceiling for the amphitheatre. Figure 21 shows that it is possible to integrate trees into the landscape. In the case of the WUR, it is not possible on the inside, however trees could be placed on the outside of the amphitheatre.

Figure 18. Amphitheatre at Afan Forest Park

Figure 19. Amphitheatre at George Fox University

Figure 20. Amphitheatre at Woods Brown

Figure 21. Amphitheatre at Swarthmore College

Wooded bank (houtwal)

A wooded bank is defined as an artificially raised earthen bank, planted with plants. Such a structure is located along the Bornsesteeg (figure 22). Right now, the wooded bank practically divides the campus in two. We think the campus would look better if there were more possibilities to look from one side of the campus to the other. Wooded banks consist mostly of local tree species and some shrubs. It often provide habitat for species of plants which do not exist outside of the wooded bank, and are therefore a unique piece of nature [47].

Figure 22. Campus map indicating the proposed location in green.

Wooded banks provide a habitat to a wide range of species. The height-differences ensure there is a difference in the water content of soil in the wooded bank, and often these structures have a side which is in the sun and a side which lies more in the shadow. This aspect gives opportunities for insects, amphibia, reptiles and sun-loving plants on the one side, and for example ferns and mosses on the other side [47]. As all straight objects in a landscape, a wooded bank provides an orientation point for, for instance, bats. Some species of bats forage in or near a wooded bank, including species that live on the campus, such as the common pipistrelle and common long-eared bat [47].

To make the campus more a whole, the view towards the other side of the wooded bank is an important aspect. Increase in the view, could be accomplished by slightly widening the already existing gaps in the wooded bank. If any trees need to be cut down, the circumstances of the Bomenverordening 2010 have to apply [48]. This process already has to be done to make more space available at the place where the bus lane crosses the wooded bank. To maintain the overall amount of nature in the wooded bank, and possibly add to it, the wooded bank should be intensified at places where buildings are close to it. The architecture of building won't come into its own when it is partially obscured by the trees of the wooded bank. Therefore, it is better to increase vegetation on these spots, to present the viewer with a nicer patch of nature and make the building behind it less obtrusive.

These more intense pieces of vegetation provide the additional benefit of providing extra shelters for birds and small mammals. These animals like denser vegetation to hide in [49]. Shrubs which have a dense cover should be preferred for this purpose.

By altering the wooded bank along the Bornsesteeg according to these general measures, a more diverse piece of nature will be created. This will offer a larger spectrum of habitats for animals and plants. Also, when using all the measures described above, the aesthetics of the campus will be improved, and there might be an increased feeling of having one campus, instead of two.

Integration of buildings with the landscape

When improving the natural diversity of the campus our opinion is that also the buildings should be included, because at this moment the direct surroundings of most university buildings is very bare or a big parking lot is the only thing visible. This creates large areas on the campus where no plants can be found, this creates a barren and industrial impression rather than a more natural one. To create a nice green looking campus the buildings should be integrated into the landscape in a better way. There are different ways of integrating the buildings within the landscape of the Wageningen campus: several suggestions are plantations near buildings, climbing plants on the side of buildings, planting trees on the parking lots and including vegetation in the stone hedges, which surround the bicycle parking lots. The different practices are described below.

Plantations near buildings

Trees can be planted near buildings to enhance plant diversity as well as to increase the natural appearance and aesthetics. They can also provide shelter and food to many species of birds, insects, and small mammals and so on. Moreover, trees absorb carbon dioxide from the air and release oxygen into the atmosphere. Furthermore, heat loss from buildings is reduced by creating a sort of cover-belt and hereby decreasing the wind against the buildings.

Care should be taken when planting near buildings, height and distance of trees should be taken into account. This varies from species to species and dependent of factors such as: size of the tree, shape and size of canopy and density of leaves, effects of light and shade, extent of root systems and demand for water, trees can be chosen to be placed at certain spots and not at others. Distance of placement from the building, also depends on the location of the tree; for instance, trees that are planted on the south side of a building require greater distance to reduce the shading effect [50].

Planting a big tree near the Forum building

The statue of the dead tree outside the Forum building does not give a good impression while entering the building, especially since "*quality of life*" is the main theme of the Wageningen university. This has been stated by many students and staff in a survey done by a group of WUR Bachelors students of Environmental Sciences, to determine the opinions of the students and staff of Wageningen UR [3]. We propose to integrate, replace or add to this sculpture a natural beautiful representative for our main theme. One of our ideas was to plant a magnificent Magnolia tree, near one of the Forum entrances as a more natural example of life's art, therefore we will further discuss this idea in the following section.

The magnolia belongs to the magnoliaceae family, which is one of the oldest, most interesting and unique plant families on Earth. The flowers have a variety of colours and the genus contains at least 210 species of which many species are well known for the unique citrus-like fragrance the flowers produce. In addition to aesthetic value, the flowers are also used for the manufacture of aromatics and the bark of the tree has medicinal value [51]. The cultivated species are mostly deciduous, but there are evergreen species too, such as the familiar southern magnolia (*Magnolia grandiflora*). We give two examples of species that can be planted on the eastern or southern side of the Forum building:

Chinese magnolia (*Magnolia × soulangeana*), is a hybrid Magnolia species cross between Magnolia liliflora and Magnolia denudate**.** It is a large multi-stemmed, wide spreading deciduous tree with large, early-blooming flowers and it can reach heights up to 8 meters and can become 6-9 meters wide. Its growth rate is considerably fast, but at 20 years of age the growth rate is slowed down. The tree is markedly upright, gradually becomes oval and at 10 years of age becomes round in shape. During the winter there are large, green buds at the tips of the branches, which In late winter to early spring open up and produce spectacular large, white flowers with a pink or purple shade, such as can be seen in figure 23. In warmer months the early flower with blossoms are formed [52]. It is a shade tolerant tree [53] and is eye-catching and attractive to butterflies, bees, and birds and the flowers are fragrant. It also requires average water, hence can be grown almost anywhere near a building [54].

Figure 23. flowers of Magnolia × soulangeana

The Kobushi Magnolia (*Magnolia kobus*), is a deciduous species of *Magnolia* native to Japan, but is also commonly grown in the north of the Netherlands [55]. It is a relatively thin, but tall tree measuring about 8-15m in height and its branches can spread to 10m in diameter. It has a relatively slow rate of growth and blooms in the early spring. The flowers are white with hints of pale pink and about 10 cm in diameter. The foliage in summer is dark green, the leaves are obovate of shape and become yellow in autumn and drop from the tree [55]. Figure 24, shows the overall appearance of the tree.

Figure 24. Magnolia kobus tree

If one of the above Magnolia species is planted on the southern or eastern side of the Forum building, the dead tree might be less imposing compared to the new and improved magnolia. The quality of life will therefore be better represented by this new and beautiful living tree and the area may be more natural looking and will attract many students, staff and animal species.

Climbing plants on buildings

Climbing plants can be grown on the external surface of buildings or structures specifically designed to accommodate such plants, in such a way green walls can be created (see figure 25 for example). To prevent adverse effects on windows, the climbers should be pruned regularly. Furthermore, the vines or "feet" with which the climbing plants stick to the surface could cause damage to the buildings if they are tried to be removed directly by pulling from the wall. Instead care should be taken if they want to be removed, in this case the base should be cut down, causing the plant to die and in this way it will come loose from the walls with no adverse effects. Climbing plants in

Figure 25. Boston Ivy on building.

general only use the surface on which they climb as a holding structure and not for nutrient uptake. Thus climbing plants should be chosen that do not cause damage to the buildings. Another thing that could be taken into account is the distance from the building, since ground directly adjacent to a building is not always suitable for plant growth, also plant pots could be taken into consideration. Further positive effects of climbing plants are that they help to enhance biodiversity, provide nesting areas for many animals, create nice looking and often fragrant flowers, they can protect walls from adverse effects from rain, wind and sun and provide an outstanding passive structure for solar management in buildings. The following kind of climbing plants generally require no supporting structures. Support is only needed in case of very smooth walls [56, 57]. Some examples of climbing plants are described below.

- Ivy (*Hedera helix*), is an evergreen slow growing climber with an average maximum height of 30 meters. It can be grown on almost any type of soil. It is a wildlife friendly plant which provides support and nesting sites for birds, especially robins and wrens. It is also an important source of nectar and pollen for bees, hoverflies and butterflies, especially the brimstone.

- Virginia creeper (*Parthenocissus quinquefolia*), is a deciduous climber with an average height of 15 meters. Its nutrient uptake rate is medium and it can be grown on any type of soil. It provides nesting facilities for birds if grown on a trellis. It is an important nectar and pollen source for bees. It is also attractive to the spotted flycatcher

- Boston Ivy (*Parthenocissus tricuspidata*), is a deciduous climber with an average height of 15 meters. Its nutrient uptake rate is fast.

- Climbing hydrangea (*Hydrangea petiolaris*), is a deciduous climber with an average height of 15 meters and can be grown on moist-loamy soil. It has an average growth rate. It provides suitable nesting site for birds. It is also an important nectar source for bees and other insects because of its attractive flowers.

Figure 26. From top to bottom: *Hedera helix, Parthenocissus quinquefolia, Parthenocissus tricuspidata, Hydrangea petiolaris*

Plantation of trees on parking lots

Parking places usually are a necessary but aesthetically unpleasing aspect on almost any location [58]. On the WUR campus, the parking places are almost bare and devoid of green. Planting trees can make them nicer to look at, or shield them more or less from public view. They also reduce water-drainage problems, and provide cooler areas on hot days due to an increase in shade on the parking lot [58]. However, a parking lot is not a natural place for a tree to grow. There are some problems that must be faced in order to grow a tree on a parking lot. The main problems are listed below [58]:

- Soil under paved areas can be extremely compacted which can cause roots to be unable to penetrate the soil.
- The soil can contain low levels of oxygen, which impedes root developments. When compartments of soils have been loosened up for tree roots to grow, the soil volume available for the roots may be limiting growth.
- Pavements may shed rainfall away from the tree, which poses a draught problem.
- Paved areas may become very hot in the sun, causing heat problems for trees.
- Vice versa, trees can also pose problems for pavement and paved areas [58, 59]:
- Shallow root systems may push part of the pavement upwards, damaging it.
- Roots can drain the soil of water, making it instable.

To negate these problems, trees on parking lots should meet several requirements [58, 59]:

- Trees should be sturdy, cold and drought resistant.
- Trees should be relatively small and slow growing to minimize water uptake.
- Trees should have a deeper root system.
- Trees should not drop a lot of branches, leafs or fruits. This will damage cars or make a mess.

So to make the parking lots on the campus more attractive, we suggest placing trees. The following trees are good examples, which meet the requirements stated above:

- Amur maple (*Acer ginnala*)
  It is a deciduous tree which grows slow. It is wind, dry soil and drought tolerant. In case of form, it is round crowned and multistemmed [60].
- Savannah holly (*Ilex x attenuata* 'Savannah')
  It is a beautiful shaped tree with narrow open pyramidal to columnar shape, is evergreen and has a moderate growth rate. Its root system is lower invasive to soils and surroundings due to higher numbers of roots with a small diameter [61].
- Chinese photinia (*Photinia serrulata*)
  The growth rate of this tree is medium and generally the trunk is small and multiple but can be made single by training [62].

Judging from the lack of information about integrating or planting trees in already existing parking lots, this is a practice which is not used a lot. Logically, this also seems difficult, since breaking up a parking lot to prepare soil for trees and to plant them, may cost a lot

Figure 27. From top to bottom: *Acer ginnala*, *Ilex x attenuata* 'Savannah', *Photinia serrulata*.

of time, effort and money. So, in case of planting trees in already existing parking area, the spaces left around the outside border can be taken into account. However, it would be a good idea to integrate more trees into the future parking lots on the southern building area of the campus.

Vegetation in stone hedges

On the WUR campus, there are iron fenced stone structures, which we will call "stone hedges", around most of the open air bicycle parking places of the Forum and Orion buildings. These stone hedges are now very bare and do not at all contribute to a natural look on the campus. They rather seem to create a sort of barrier around the buildings, which cause the buildings to look less integrated into the surrounding landscape. However, it is possible to let vegetation grow on these structures. By doing this, the stone hedges can be made more attractive and this will create a more natural view in front of Forum and Orion. It will also stop students from passing over them, hereby minimize damage caused to these stone hedges and nature on them. Moreover, it will create small habitats for insects and will help in integrating the buildings within the nature of the campus.

Lichens, mosses and higher plants are possible to be incorporated in this area. Lichens are the symbionts, which are the first of all plants to thrive on any bare surface, before other plants appear. They can be taken under consideration for this purpose as they have the capacity to survive on a large variety of substrates, including stone as well. But, lichens can give the objects on which they grow the apprehension that they somehow look dirty. Therefore, mosses and higher plants are given priority on placement within the stone hedges.

Growth

In a natural environment, there are two modes of development of vegetation on stone, which follow one another in time [4]. During the first developmental stages, the stone had been exposed to environmental factors which provide conditions suitable for the growth of bacteria, fungi and lichens. After a while, the conditions on and in between the rock surface, are improved before the second mode of development starts. During this time, there is formation of a substrate that is suitable for the germination of higher plant seeds. Atmospheric dust and birds excretes which are present most of the time, also contribute to this substrate formation (see figure 28).

In the second mode, plants will make use of the moisture available from natural precipitation and atmospheric dust. These plants also grow naturally within the surface of building materials. The type of species of plants depends on the porosity of the stone. The mosses are the pioneers for the later vegetation, as they provide the substrates on which higher plants can flourish [63]. However, there are also higher plants which can be hardy pioneers such as mosses, examples are the slender sow thistle (*Sonchus tenerrimus*), which is an herbaceous annual flowering plant and Pellitory of the wall (*Parietaria diffusa*), an herbaceous perennial [4].

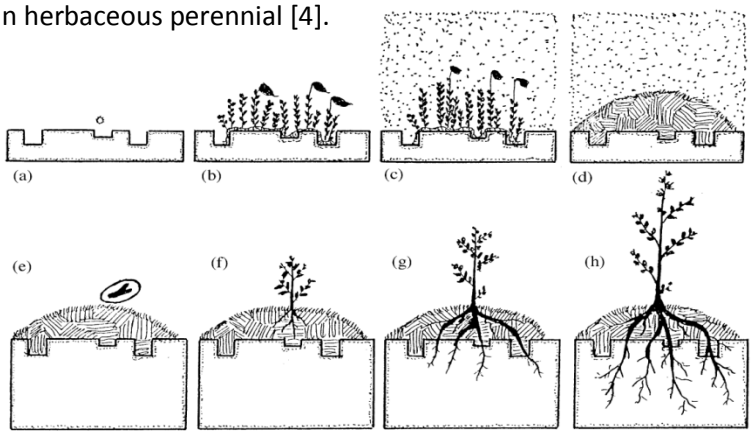


Figure 28. The stages of a second mode of wall colonization. A moss spore (a) falls on porous stone, such as travertine, and develops (b). Atmospheric dust collects on the moss (c) forming a small amount of substrate (d). A seed falls on the substrate (e), germinates (f), grows (g) and Flowers (h). The moss does not damage the substrate but the plant roots penetrate it." (Adapted from Lisci et al. 2002 [4])

However, in the situation of the campus, plants are not only chosen based on their natural capacity to spread, but also on their aesthetics and their capacity to survive in these somewhat inhospitable environments. The stone hedges are dry environments during summer and only a little substrate might be available to grow on. Therefore, extra substrate could be added on and in between the rocks of the stone “hedges” before plantation. This substrate should be adequate for growth of stone growing plants. Also care should be taken that not all the substrate will wash away during heavy rain, therefore plantation might be more efficient during warmer periods, so that the plants can get a head start and root themselves and their substrate firmly in the stone hedge structures.

Plant species

In terms of choosing which species should be planted, herbaceous perennial species have a higher priority compared to annuals or shrubs and trees. Because, they will cause minimum damage to the stones and iron fence material and can stay for multiple years. They are often more hardy plants and require the least maintenance, also they often create low staying, nice looking, flowering vegetation [4]. Below, we give three examples of herbaceous perennial plants that cause minimal amounts of damage to stone structures on which they live.

Figure 29. From left to right: *Asplenium trichomanes, Cymbalaria muralis, Sedum album L*

For more information on species, see appendix 13, it contains a list of stone growing plant species, of which those highlighted in green are useable species and those in orange should better not be incorporated. They are nonetheless added in the list to give a comprehension of why it is important to take the plant species into account.

By incorporating plants into the stone hedges, which separate the bicycle parking places from the bicycle paths, this will give these hedges a more natural appearance and will help integrate the buildings into the landscape of the campus, while at the same time contribute to more diversity for animals.

Artificial nesting sites

Bird and bat boxes

To attract more birds and bats in the campus, bird and bat boxes could be fixed to the walls outside the building as well as trees around the campus, see figure 30 and 31 [64]. The main function of these boxes is to afford alternative roosting habitats. Bird boxes mainly attract owls, common swifts, starling and sparrows. These boxes should be placed in areas which are not exposed to midday sun. Also protection from some predators like cats, rodents and larger birds are necessary. Using wire mesh guards above and below the box can secure the birds and bats from predators.

Figures 30. A bird box fixed to a

Figures 31. Example of a bat box

Hedgehog house

Hedgehogs could be encouraged to come to the campus by offering proper habitats. Hedgehogs are very punctual and tend to go away at a distant place for feeding and come back to their habitation every day. While travelling long distance they could however be killed by traffic. Natural looking hedgehog houses could be placed at appropriate places in the campus to supply a safe hiding place, so they don't have to travel. Hedgehogs are environmentally friendly and keep the environment clear by devouring pests of plants such as snails and slugs.

Figures 32. Hedgehog house inside a garden

Boxes for bees

To make the WUR campus more pollinator friendly, artificial nest boxes could be placed throughout the campus (figure 33). The common nesting sites for solitary bee species are hollow stem cavities, bored cracks in timber and brickwork or in the ground. Many studies have shown that solitary bees are perfectly able to nest in artificial nest boxes, red mason bees (*Osmia rufa*) for instance, occupy artificial nest boxes made up of metal food containers filled with drinking straws [65]. The most common bee and insect species shown to nest in artificial nest boxes are the subtropical carpenter bee (*Xylocopa fenestrate*) [66], the orchid bee (*Euglossa atrovenata*) [67], the leaf cutter bees (*Megachile rotundata* and *M. apicalis*) [68] and the European earwig (*Forficula auricularia*).

Figures 33. An artificial nest for solitary bees made from a tin can and hollow plant

Bumblebees are also known to accept artificial nest boxes made up of different materials like wood, bricks or tiles. The boxes could be placed on the ground surface [69], underground in flower meadows (see figure 34) [70], or could be attached to tree trunks [71]. On the campus, bumble bee boxes could probably be placed in the proposed flower meadows as well as on tree trunks

Figure 34. Underground bumblebee box in flower meadow

Nests for aquatic birds

Floating platforms

Many species of waterfowl prefer artificial floating platforms because they provide substitute nesting sites that offer protection from predators and prevailing winds. The platforms are covered with straw, grass, or hay (Figure 35). Nest materials are kept at the bottom of the platform to prevent it from propelling off. The ducks are also seen much near floating platforms. These kind of natural looking platforms can be put on the water bodies of the campus to create favourable environment for waterfowl like mallards (*Anas platyrhynchos*), or mute swans (*Cygnus olor*) [72].

Figure 35. Figure Floating platform for waterfowl

Nesting cylinders

Nesting cylinders are favourable nest sites for some species of waterfowl that choose overhead cover. This cylindrical house is made of dried grass, hay or other vegetation (Figure 36). The house is built up on a wooden platform attached to poles extending from the water. The poles should protrude sufficiently above the water surface to protect the house during flooding [72]. On the campus, they could be placed in the more remote areas, such as near the pond at Zodiac or the proposed wetland area

Figure 36. Figure Nesting cylinders for waterfowls

Maintenance of artificial nests

Artificial nesting sites can be checked out during the nesting season to know their efficiency and success, to take away unwanted or exotic species. Moreover, the nests should be cleaned after the juveniles are fledged to make it favourable for next nesting efforts. Nests should be checked quickly, because some species of birds and mammals can endure some degree of levels of human annoyance and others do not. Sometimes, nesting birds are attacked by parasites like mites, larvae of blowfly and other pests [72], so to avoid this infestation, the nest of the box can be tapped gently so that the pests are dropped at the floor of the box and afterwards the pests can be swept out the box.

Green connection Blauwe Bergen and Dassenbos

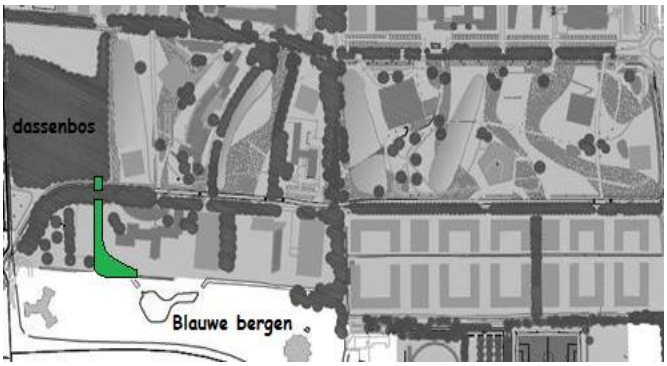


Figure 37. Map of the WUR campus, with areas of importance indicated in green

Currently, a bicycle path is situated between the Dassenbos and the Blauwe Bergen. In the near future, also a new bus lane will cross the campus and will be placed next to this road. The extra motorised traffic, but also the added width of the road, may inhibit animal movement across the future bus lane [73].

To overcome this problem, figure 37 above shows the placement of the idea of a new connection between the Blauwe Bergen and the Dassenbos. Connectivity of green structures and natural areas, between the Dassenbos and the Blauwe Bergen could be increased in several ways.

On the field North of Dijkgraaf, increased connectivity can be established with the Blauwe Bergen, by creating more natural borders. A connection could be made between the field of Dijkgraaf and the Dassenbos, crossing the bus lane and cycling path. The edge of the field can have increased vegetation. Trees, bushes and higher grasses could be added which would make this area more accessible to animals coming from both sides. Furthermore, a plan is to increase the overall amount of plants on the field, because it is now quite desolate.

To increase the connectivity for small, terrestrial mammals between the Dassenbos and the Blauwe Bergen even more, an underground connection “tube” could be added, for example made from concrete, to connect both sides of the road. We estimated such a tube would have to have a length of approximately 10-15 metres, based on a future bus lane of 6-8 metres [74]. We could not find the exact costs for such a length of concrete tube, but when extrapolating from projects in which similar constructions were used, we estimated this would cost approximately 25.000 euro [75]. The lowest estimated costs we could find were approximately 1.000 euro per metre, not including extra practices, such as breaking open a road [76].

As a lower-cost efficient alternative to an underground connection, the area could be optimised for crossing the road aboveground. This can be done by making a sort of bottleneck, where the width of the bus lane is decrease and consists of vegetation on both sides of the road. Small animals cross the road more often on places where the road is narrower [73]. In this case increased vegetation at certain places near the road, could lead the animals to the best crossing area. Another possibility to guide the animals to the passage is a structure which could be planted right up to the passage on both sides. To increase the effectiveness of this guiding structure, measures should be taken to block animals from the road at other places and guide them to the passage. This could be done by placing small natural fences between the road and the nature areas on both sides of the road except for the passage. This will only work for really small animals, like amphibia, other animals will be able to get over it more easily.

For birds and small tree living mammals, such as bats and squirrels, connectivity can be increased by using a hop-over. A hop-over is a structure that is integrated in the surrounding area, and crosses an open area at the level of the treetops. Without a hop-over, bats are more likely to cross the road at the height of a car, and are thus more likely to get hit [77].

By implementing these measures, animals may cross the road more easily than without them. This will enhance the chances of survival for separate animals by creating a larger living area with more food resources and resting places. It will also improve gene-flow between these two nature areas.

Green connection between the East to West of the campus

Because the middle part of the WUR campus is very open it is not likely that animals will cross. To improve the corridor function of the campus we suggest making two new green connections from east to west. In this way a better connection is created between two big natural areas, the Veluwe and the Binnenveld. This will eventually improve the functioning of the ecological network (EHS, Ecologische Hoofdstructuur), which in turn helps to improve the biodiversity and sustain the wildlife in the Netherlands [78].

Figure 38. Map of the WUR campus, with areas of importance indicated in green

There is already a green connection planned next to the road north of the NIOO building, which will hopefully bring more animals to the campus. Furthermore, some steppingstones are going to be build, which improve the connection between east to west for animals [78]. But there is still a debate if these steppingstones are really going to function the way they are intended [1].

That is why we suggest to also creating two extra, different green connections from east to west, hereby improving the connectivity for animals to cross the open area in the middle. One connection will run south of the Droevendaalsesteeg and one north of the planned bus lane (see figure 38). The one north off the bus lane will start in the south-east corner of the campus, alongside the Orion building and will go on until the Bornsesteeg. There is a strip of grass between the bike path and a small footpath which is almost empty, which only contains some trees near Orion and near Bornsesteeg (figure 39). The one next to the Droevendaalsesteeg will start at the north-east corner of the middle part next to Atlas, will continue alongside the Forum building until the Bornsesteeg. There is now a strip of grass with a line of trees between the Droevendaalsesteeg and the bike path (figure 39).

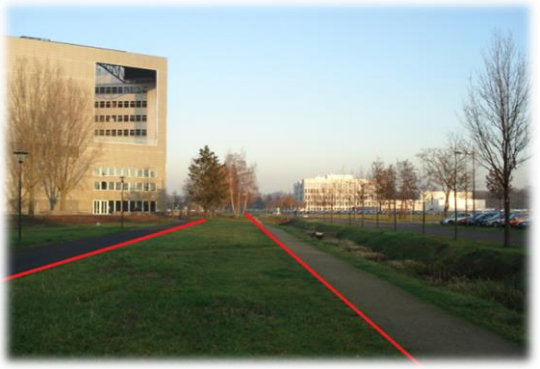


Figure 39. Top, current situation of the field next to future bus lane indicated in red, bottom, current situation of the field next to Droevendaalsesteeg indicated in red.

In order to create two new green connections we propose to create a natural park like looking strip of low vegetation, some higher vegetation and more trees. Alongside the droevendaalsesteeg there is already a line of trees so here only low vegetation and some higher bushes are proposed to be placed. These strips will not only function as a green connection between east and west but will also create nesting places, hiding places and foraging areas for different kind of animals. Below we will give an example of some species that can be used to create this green connection

Possible trees species:

We suggest planting trees which can easily be maintained and will not grow very big, to keep the looks on the campus open. Also, the appearance of the trees is very important because this will contribute to create nice tidy looking strips. The trees should be able to withstand the cold weather of the Netherlands and be able to grow on wet soil. More research and soil analysis should be done to know more about the soil's physical and chemical characteristics. Here we will suggest some trees species which fulfil the requirements stated above.

- Honey locust (*Gleditsia* triacanthos): This tree is already present on the campus, so it is known that this species can survive in the environment. It is a medium sized tree with long curly seeds. This tree is already used in urban environments. The seeds of these trees are of much value for wildlife; they are a good food source for different kind of birds and small mammal species. Also, the tree grows fragrant flowers, which attract bees [79].

- Apple *(Malus sp.*): In the campus there are already different species of *Malus* present. So we assume that at least some of the *Malus* species are able to survive in this environment. Its flowers are attractive for different kind of pollinators because they contain nectar and pollen. Most of the *Malus* trees have quite a long flowering time making them very attractive in an esthetical way. Furthermore, some animals and birds eat the fruits of the *Malus* trees or use it as nesting place [80, 81].

- Stone fruit (*Prunus sp*): These trees prefer to grow in a well-drained, moisture retentive soil. Pruning is rarely necessary, but when this is unavoidable it should be done in late summer to minimize the chance of some diseases. Pruning can be done in order to maintain a small size, which is nice to for keeping the open view on the campus. Several insect species are attracted to this tree, because of the fragrant flowers and in autumn the fruits can be used as a food source for fructivorous birds [82].

- White willow (*Salix alba*): It is a common tree in the Netherlands and usually grows next to small water bodies [83]. With the proper maintenance it can get different shapes and can be kept small. One way to prune it is like a pollard willow. It is then best to prune every branch of the

Figure 40. From top to bottom: Gleditsia triacanthos, *Malus 'Radiant',* **Prunus padus, Salix alba**

tree close to the trunk every year, if the tree already has a relatively thick trunk base [84]. In this way the tree stays relatively low and still has a nice appearance. The tree provides good hiding and nesting spaces for birds and small mammals, like for instants the mallard (*Anas platyrhynchos*) which is present on the campus [85].

Possible shrubs and woody plant species:

In between the trees we suggest to plant some bushes. To keep the looks on the campus open we suggest to only plant a couple of bushes, with some distance apart from each other. Also, like the trees the bushes should be maintained to have a nice and friendly appearance and to make sure they will not grow too big. Another important aspect is flowering time, the right composition of species has to be chosen to create a large spread of the flowering time during the whole season. But also here soil analysis is needed to know the exact characteristics of the soil on the campus. Here we will suggest some shrubs species which fulfil the requirements stated above.

- Butterfly bush (*Buddleja davidii*): This deciduous scrub is part of the family of *Scrophulariaceae*. It can grow along riversides and pastures and can become very large. Therefore some maintenance has to be done every now and then, because it will otherwise grow out easily and form a dense cover [86]. It has beautiful fragrant flowers with a distinctive scent which attract a variety of butterfly species (*Nymphalidae*, *Satyridae*, and *Pieridae*) [87].

- Hawthorn (*Crataegus monogyna*): This species belongs to the family of *Rosaceae* and is also already present in the campus in some stepping stones. This bush also increases the corridor function of the strips because a large number of insects are associated with this shrub and it is a good food source for some **fructivorous** bird species. It is an easy grown plant which prefers well drained soils and also tolerates drought [88-90].

- Common mallow (*Malva sylvestris*): This species belong to the *Malvaceae*. It is very easy to grow on normal to wet soils. It is a perennial plant which is easy to maintain. However it can grow quite fast and care should be taken that it will not overgrow other plants. It has beautiful flowers that help to improve the attractiveness of the campus and which also produce a lot of nectar which attract a lot of different insects. For example, it is also a host plant for the Painted Lady butterfly *(Vanessa cardui)* [89, 91].

Figure 41 From top to bottom: *Buddleja davidii, Crataegus monogyna, Malva sylvestris*

Possible Herbaceous species:

Herbaceous species will mainly be used to cover the ground. These species remain low and will create good hiding places for small animals, like the Common vole (*Microtus arvalis).* However, they are also nice to look at and cause the borders of the campus to appear less empty. Another aspect what helps also helps with the looks is flowering time, also here it is important that the right composition of species are chosen to create a large spread of the flowering time during the whole season. Here we selected some species which will grow on wet grounds. Also we selected different colours of flowers to create a nice appearance

- Meadow anemone (*Anemone canadensis*): This species belongs to the Ranunculaceae and is a perennial plant. It grows on wet open areas and will stay low. This species does not produce nectar, only pollen. Mostly solitary bees will use this pollen as a food source. It will cover a lot of ground and will provide good hiding places for small mammals and birds, but some maintenance is required to keep it in proportions [92].

- Lavender (*Lavandula angustifolia*): belongs to the Lamiacaea and is known for its nice fragrance and appearance. It is able to attract many beneficial insect like hoverflies and pollinators like bees and butterflies. It is however important to keep aphids (sap-sucking insects) away from this plant, since it is quite vulnerable to them.

- Red campion (*Silene dioica*): This species belong to the Caryophyllaceae and is already present on the campus. This is a perennial species which does not spread very fast. It grows on open places and needs fertile soil. It produces high quantity of nectar and is very attractive for bumblebees, who are the main pollinators of this species [93].

- Bird's-foot Trefoil (*Lotus corniculatus*): This species belongs to the Fabaceae and is most common on meadows. It can grow on wet soils and the flowers are pollinated by a variety of bees [89, 94]. It can also fixate nitrogen [95], this can help because it makes more nitrogen available for other plant species [96].

Figure 42. From top to bottom: *Anemone Canadensis, Lavandula angustifolia, Silene Dioica, Lotus corniculatus*

Overall conclusion

Here we gave a quick overview of species which can be used to create the flower strips. But more research has to be done on different topics. For instance soil characteristics like texture and nutrient availability and species composition. The different relations between species should be kept in mind, such as species which will fixate nitrogen and using species that are not very competitive. If some extra research is done, it is also possible to only use indigenous species to blend into the environment more. At the end, with the use of different plant types, from tree species to herbaceous species, eventually nice tidy looking strips of vegetation can be formed. To keep it this way it is necessary that they should be maintained, to ensure that: bushes will not grow too big, or some species have to be partly removed because they grow faster than others. In this way a nice park like appearance can be created, which fits with the open looks of the middle part of the campus. Next to good aesthetics, the plant and tree species which will eventually be used should also be able to function as animal habitat. They are able to function as hiding places, nesting places, food resources and a green connection between the east and west side of the campus. In this way a variety of animals like insects, birds and small mammals can use it in different kind of ways.

Green connection between Orion and Sport Centre:

Increasing connectivity between nature areas on and around the campus is one of the goals of this project. One of the areas which already have plenty of opportunities for wildlife is the strip of vegetation, that is situated on the north border of the sport centre the Bongerd. However, the cycling path between the Bongerd sports centre and the Orion building (figure 43) is almost devoid of any plants and trees and looks very bare (figure 44). Nowadays, animals that want to cross between the Bongerd and Forum area must use the open fields and in the future this crossing will be in between the new buildings.

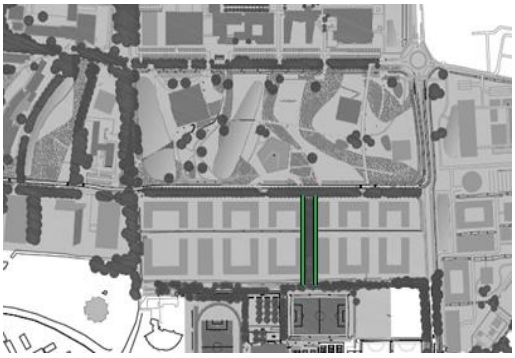


Figure 43. Map of the WUR campus, with areas of importance indicated in green

To create a better connection for animals to cross, we propose to create a green corridor on both sides of the bike path. This green corridor will consist of a line of different kind of trees with some bushes and herbaceous plants in between. This line will be comparable to the modular plan concerning the two strips connecting the east and west side of the campus. The same composition of species should be used and it will also need the same maintenance mentioned in this plan, in order to create more natural aesthetics. In this way a network of green connections will be created on and around the campus, which can be used by animals. For suggestion of species, see the part about the connection between east and west of the campus.

Figure 44. Top, current situation of connection between campus and the Bongerd indicated in red, Bottom, current situation of the crossing at Orion.

To create an even better connection, the same herb species can be scattered around in between the sport fields to create a better transition between the sport facilities and the green connections. It is not possible to connect the two strips because of the bus line. The intersection were the two strips will connect has to be decreased in size, because It is now too big to cross for small animals (see figure 44).

In order to connect the area between the strips from the Bongerd and the strip between Orion and the Bornsesteeg a small underground tunnel can be build, in order to create a safe crossing for small animals, like amphibia. This would be the safest option but can be very expensive. Another option, which will cost less, is to create a bottleneck (as described in the green connection between the Dassenbos and Blauwe Bergen) where the width of the bus lane is decrease and only one bus can pass each time. This will create a better crossing point for animals because animals will cross narrower roads more often than big ones [73]. By implementing these measures, the strip of nature north of the Bongerd will be more connected to the garden around Orion, the stepping stones of the ecological corridor, and through these areas, to the rest of the campus.

Flower meadow strips

The vision of the WUR is to "have large, open spaces with low vegetation, from which the buildings rise as mighty monoliths" [3]. To create some height differences in between the grassy area, meadow flower strips can be created. This can be done at three places, in front of the Zodiac building, east of the Forum building and north of the Orion building (see figure 45). The event terrain will remain as it is right now. The idea behind the flower strips is that this will create some variety in the bare middle part of the campus, according to a lot of students [3]. In the original campus plan by the BenB landscape architectural bureau, it was already the intention to create height differences with different grass species but this did not work properly (personal communication Ad van der Have). So that's why we suggest creating height differences with a mixture of meadow flowers and some taller grass species. It is even possible to make these strips with a small hill shape of not more than 10 cm high with a low slope. This will also help to make a better distinction between the grass and the meadow flower strips during winter and it also helps when the area is too wet for flowers to be able to flourish. In front of the Zodiac building two circles of flowers can be created in the meadows with in the middle a big tree. The composition of species should be a little different here because of the shading of the tree.

Figure 45. Map of the WUR campus showing flower strips indicated in green

Here we will focus on the three strips. The meadow flower strips add more colours in the middle part of the campus and create some more niches for students, staff and animals. Also the stepping stones can be included in the strips and are in this way, more integrated into the area. Now it seems like the stepping stones rise from a perfectly mown field, which is not very appealing. If they are surrounded by flowers, they will seem too slowly blend with the surroundings. Insect visits are very important to maintain a high number of flowers, if there are no insect visits there is a significant loss of seeds [97]. Creating an insect garden on the campus area will make sure there are enough insects to help the flower meadow strips survive. Also a lot of small mammals use the flower meadows as hiding places, like shrews and other small rodents for instance. The highest density of small mammals can be found in the part with the highest number of flowers [98]. These strips should also be at least 10 metres wide, to prevent a high mortality due to predation [99]. To make a flower meadow a lot of species can be used. Here we will discuss some of them but many more species are possible.

- English ryegrass (*Lolium perenne*): Is a species of high grass which grows on medium wet to dry soils. It is also found a lot on disturbed ground and can grow to a height of 90 cm [89]. These will help by creating a nice height difference within the normal grass which is used now.
- Field poppy (*Papaver rhoeas*): This species belongs to the Papaveraceae and can live in between grass species. It can grow on on medium wet to dry soils and can grow to 60 cm in height [89]. It has beautiful red flowers which give the strips a nice appearance.

Figure 1. Picture of *Lolium perenne*

- Cornflower (*Centaurea cyanus*)**:** This species belongs to the Asteraceae and is often seen in the same place as the *Papaver rhoeas (*see figure 47*)*. It will grow on relatively dry soils, so a low mound has to be made to create a drier flower strip. This species is also used in insect gardens, because it attracts bumblebees [100].
- Common yarrow (*Achillea millefolium*)**:** This species also belongs to the Asteraceae and can grow on medium wet to dry soils. It will grow to a size of 20-100 cm and is perennial. Perennial species are needed to also keep a different look in winter. It is also a good food source for a variety of insects [101].

Figure 47. Top, *Centaurea cyanus* and *Papaver rhoea,* Bottom, *Achillea millefolium*

For the exact species composition more research has to be done like defining the soil characteristics of the area, which beneficial relations between specifics species exist and the dominance of the species. Some maintenance is required to overcome some of the problems, such as making sure the strips do not mix together after a while and regular mowing maintenance has to be performed alongside the strips to prevent the meadow flowers from spreading to nearby areas. Also mowing of the strips is necessary one or twice a year to prevent one dominant species to overgrow the rest of the species. The timing of mowing is difficult. Mowing later in the year (August and September) creates more opportunities for nesting birds, but if this regime is maintained for several years, the species diversity will decrease, and coarse grasses and other dominant species will become the main plants of the area. Late mowing is good for birds and insects in a short timeframe, but in the long run it will cause a decrease in nectar-producing plants [102].
Also the amount of mowing is very important for keeping flower meadows species rich and this differs between species composition [103]. Therefore timing and amount of mowing has to be taken into account by selecting the flowering species.

Another practice which can be used is natural grazing. Grazing is often better for grassland than mechanical mowing [102]. Grazing allows nutrients to re-enter the grass-land ecosystem, which is beneficial to plants requiring these nutrients in the poor soil on campus. Also, the hooves of larger herbivores create holes in the grass cover. These holes are an opportunity for coloniser species, and contribute to the natural and species diversity of the grassland [102]. However, large herbivores may also reduce species diversity by selectively eating several species. For instance, sheep prefer to eat flowers over regular grass. If you want a flower meadow with plenty of flowers, it would be wise to deny large herbivores access to these strips from spring to late august [102].

A second option is, instead of making whole strips, to only create some patches of meadow flowers. They are then still able to function in creating some niches and give colour to the middle part of the campus. These patches can be created around the stepping stone to integrate them more in the landscape. The height difference between the stepping stones and the grass is in this way less abrupt.

Fruit garden

In order to increase the Natural diversity on the WUR campus and to incorporate opinions of students and staff more, we propose to make a fruit garden. One can see from the conducted surveys that most of the people want to see more trees on this campus, therefore we are going to include fruit trees in our ideas. We propose to include this fruit garden in the same location where the amphitheatre is planned, to include trees surrounding the theatre or next to it. The specific place has to be decided in the future including the opinion of other instances in the campus, like the facility department. Figure 48 shows the proposed location for the fruit garden.

Figure 48. Map of the WUR campus, showing the proposed location for the fruit garden, indicated in green

The plan is to incorporate wild natural fruit varieties, this also creates an area with a cultural-historical value, where students and staff can walk around and enjoy the atmosphere. But, also a fruit garden can have a high natural value since it is a source of food for insects, birds and other small animals, provides more nesting places for birds, produce flowers and at the same time increase the attractiveness of the campus. Additionally, we would like to propose, that the WUR as a life sciences university incorporates its scientific knowledge more into the landscape. For example the fruit garden could also be seen as a possibility to use as a kind of experimental field on for example biological control of insects.

In the future we would like to see this fruit garden as a self-reliant, independent garden, as can also be seen in a permaculture garden. However, to know if this is possible this project should start with a trial and error approach and find out what the constraints are that we are going to face and then start to look for the best options to overcome them.

We are going to select species that we know are grown in The Netherlands and also species that can contribute to increased natural resources like food, nesting places and shelter for animals. We will describe species that can attract insects in order to increase the diversity of insect species which could help to control pests in a biological way and the nectar and pollen can be used as a source of food. The trees themselves can be shelters and can be used by insects to overwinter and helps them to survive until the next season.

We are not focusing on producing a high fruit yield, because this is not the aim of this project and because, to have a high production one needs to spend a lot of time and resources on management. We will focus on selecting species that are likely able to growth in this environment and will increase the biodiversity.

Environmental conditions of Wageningen Campus

When selecting which fruit species can be grown on the campus, environmental conditions such as soil type, temperature and precipitation of Wageningen should be known.

Soil: The soil on the campus is very disturbed, this is caused by machine work that has been done in the past several years while all the edifices have been constructed (personal communication with Andre Van Amstel). Because of all these disturbances, the soil's parent material is mostly removed

and because soils take a long time to settle it is difficult to know what type of soil there is now. The average ground water level of the campus (GHG) is less than 0.4 m belowground (groundwater table III) [1].
Climate: Another important aspect is the climate in The Netherlands. There is a temperate maritime climate influenced by the North Sea and Atlantic Ocean, with cool summers and moderate winters. Daytime temperatures vary on average from -1°C to 7°C in winter and from 13°C to 23°C in summer [104]. Since the country is relatively small there is little variation in climate from region to region, although there are less influences of the marine climate inland.
Precipitation: Rainfall is distributed throughout the whole year, there is a dryer period from March to April and the most rain occurs in December [104]. According to J.G. van Minnen et al, 2012 the total annual precipitation has increased by more than 20% in the last 100 years and the frequency of very heavy rainfall has also risen sharply [105].

Selection of species

Apple (*Malus spp.):*
In the Netherland the production of apples in 2011 was around 418.000 tons. The species that are produced are *Malus pumila, Malus sylvestris, Malus communis* and *Pyrus malus* and they can all be used on the WUR campus. The apple belongs to the subfamily Pomoideae, the pome fruits and it is the most ubiquitous and well-adapted species of temperate fruit. It is grown in high latitude regions of the world where temperatures may reach –40°C [106, 107]. The genus *Malus* consists of about 27 wild species, of which most are self –incompatible. This means that two different species of *Malus* are necessary to induce pollination and hereby the formation of apples [106]. The apple tree needs a period of winter chill to break seed dormancy [107]. This ensures the seeds of the apple can sprout in the next year. Cultivars vary widely in their chilling requirements, although the majority of the cultivars are in between 800-1200 range of chill units. In The Netherland the temperature conditions usually fulfill this requirement [107]. In the Shaltout and Unrath model (1983) the maximum chilling efficacy is at 7,2°C, there is zero response below 1.1°C and higher than 15°C during winter period [108].

Soils
Apple trees should be placed in areas with better drained soils, because poor soil aeration increases the incidence of some tree diseases. Apple trees can grow in a wide range of soils from medium textured clays to gravelly sands, however the best crops are found on fertile sandy soils and loams. Regarding the soil depth, the root penetration of an apple tree is quite variable, although most roots are generally located within the surface until 0.8 m depth [109]. A greater rooting depth can enhance tree growth and production by increasing tree access to nutrients and water, however some limitations of shallow depth can be overcome by effective irrigation or soil amendment. It is know that the restriction in rooting volume reduces the vigor of the trees and the fruit size [107].
Thus, because of the campus' soil conditions, there will probably be less vigorous trees and smaller fruits. However, we are not focusing on the yield of the apple trees, but rather want to include them to increase the biodiversity and improve the cultural-historical value of the landscape, therefore it is of no importance if the fruit tree yield is low. Additionally, we rather propose to incorporate smaller trees because they are easier to maintain and are safer in case of strong winds, which can occur frequently on the campus. Therefore, the soil limitations of the campus which keep the trees small can be an advantage in this case.

Pruning

This practice can be done to keep trees small. Removal of the branches not only removes stored carbohydrate and nitrogen reserves, but also reduces potential leaf surface and growing points. Pruning reduces root growth as well and the new root growth will be delayed until shoot growth, in response to pruning, occurs. This is because there is an equilibrium between the above and below ground components of an apple tree. Removal of a portion of either the top or root system slows growth of the other, until the balance is reestablished [110]. Most pruning on apple trees is done when they are in a dormant state during winter, however in areas with low temperatures during winter the susceptibility to winter injuries is increased. The exact temperature required to induce winter injuries varies due to many factors, such as previous exposure to low temperature, type of cultivar, amount of roots (rootstock) and the age of the tree. Winter injuries can occur at low temperatures in the range of -23 to -49 C [107].

Soils and Nutrient management

Apple trees require 16 elements for the completion of their life cycle. Among these are of course carbon, hydrogen and oxygen, which are important non mineral elements and major constituent of organic materials. Furthermore nitrogen, phosphorus, sulphur, potassium, calcium and magnesium are needed. It is not easy to calculate the exact amount of minerals that is required by an apple tree, because this depends on the amount that is already present in the tree (trunk, roots and leaves) and the amount that is present in the soil [107].

On the campus it is possible to include soil organic matter via mulches and green manure which is rich in nitrogen compounds, or include plant species that are able to fix nitrogen to increase the amount of nitrogen in soil. Additionally, it is necessary to do a soil analysis test in order to know the amount of nutrient that is present.

Pollination

Apple trees need bees for their pollination and creation of apples, because they are self-incompatible. Bees, bumble bees and butterflies are attracted by apple trees because they contain blossom flowers, from which they collect pollen and nectar [81, 111]. Furthermore, we also propose to create an insect garden that will help to improve the apple pollination by increasing the amount of insects in the area. Apple trees have very abundant flowers and a long flowering time [112], making them very attractive to look at.

Additionally, more than 29 species of birds are attracted to *Malus sp*. and they use this trees as a source of fruit and nesting sites [81]. In order to make the fruit garden more sustainable and self-reliant, the insect garden would help to naturally control any pests that can affect apple trees by increasing the Natural enemies. There is literature that states that the landscape composition affects the diversity and abundance of the natural enemy, more complex landscapes may give rise to suppressed pest populations. However, these effects should not be generalized because only relatively few studies have been done [113].

***Cherry (Prunus avium)*:**

Prunus avium is commonly called wild cherry or sweet cherry and belong to the Rosaceae family. The cherry is native to Europe, North Africa and western Asia. There are some *P. avium* already present in the campus. Cherry is a lowland species, rarely is it found above 300 m high. It is good adapted to winter conditions, however flowers can still be damaged by late spring frosts [114].

The Cherry is a fast growing, medium sized tree with attractive flowers. Cherry trees are also light demanding species, except when very young. It has a good apical dominance so in its developing stages it retains a single straight leading shoot. It has to be planted with a minimum distance of 3 m from one to another, because the branches tend to grow wide [114]. The most important reason why to include this species is because it is good for wildlife, its fruits are eaten by many small mammals and birds [114]. According to Gökçen Firdevs Yücel, 2013 the genus Prunus sp, is used as a source of food by more than 84 species of birds. The attractive appearance of the tree and its flowers can make the campus even nicer [81].

Figure 49. Picture of *Prunus avium during blossom*

Soils

Cherry trees can grow reasonably in many type of soils, but its best performance is in deep and silty soils with a good water supply and a pH of that ranges from 5.5 to 8.5; It is commonly planted in woodlands edges. Because it needs deep and well drained soils care should be taken to avoid sites prone to waterlogging, furthermore trees should be located on higher parts on the campus, or placed on small heightened agricultural ridges [114].

Pollination

Flowering time is from early April to mid-May and fruit ripen in June and July, they produce a good seed crop every 1-3 years. In natural conditions the seeds are disseminated by birds [115, 116] and small mammals [114], which cause the trees to spread. Additionally, Cherries are also dependent on insect pollination, but only 3% of the fruits is produced by open pollinated flowers. The insect garden that we are proposing will help to increase the amount of insects and wild bees and will thus increase the fruit set of the cherries and the natural control of pest [117]. Furthermore, it is know that some butterflies are also attracted to Prunus spp. Flowers [81].

Association with walnut

Preliminary studies show that the association between Cherry and the Walnut species *Juglans regia* increases the height and growth of the cherry tree [118] and the association between cherry and the hybrid walnut tree (*Juglans nigra L. x Juglans regia L*) increases the diameter growth of both trees [119]. Additionally, pest and diseases of walnuts and cherries are decreased in mixed plantations compared to monocultures of only cherries [120]. Consequently, associations between different species can play an important role in cherry cultivation, especially in sites with poorer soils [118].Therefore, we will propose to include Walnut in the fruit garden as well and suggest its placement near or in between cherry trees.

Walnut (*Juglans spp*):

There are 20 species of Juglans worldwide, but only *Juglans regia* is native to south-east Europe, other species are native to eastern Asia and a greater number is distributed across North America and the Andes in Chile [114]. Probably the Black walnut (*Juglans nigra*) and common walnut (*Juglans regia*) will perform better in the climate of The Netherland than other species. It is known that Blank

and Common walnut can grow in the south of Britain [114]. We are proposing to include walnut, because it is know that walnut fruit forests represent a valuable hotspot of biological diversity [121]. In forest, the general rule is that the higher the tree diversity, the higher the diversity of birds and an agro forestry site appears to be a promising habitat for the promotion of bird diversity [121].

The trees flowers during June, and the seed ripen late in September or beginning of October [114]. Although they are best adapted to warmer conditions, late spring frost hardly damages walnut trees. In order to reduce the risk of frost damage later in the season, trees should be planted in more sheltered places, on mid slope positions with a south or south-west orientation. It requires at least 6 months with an average temperature of 10°C to produce fruit [114] and [122]. Walnut trees require a medium soil texture to root deep, because trees grow well in areas where there is at least 60 cm of soil depth [114]. Also they are not able to withstand excessive water or drought, thus they have to be located on higher parts of the campus, or be placed on small agricultural ridges to improve the soil requirements. Some studies showed that the walnut can benefit from being planted in mixed stands, particularly with nitrogen-fixing species [123]. Because walnut trees need a fertile soil it is therefore also a good idea to include some nitrogen fixing plant species in the fruit garden.

Pruning and Growth associations

In order to create a walnut tree with a single straight stem, it is necessary to remove lateral leader shoot which compete for dominance with the main trunk. This pruning will have to be done in the first few years after planting [114]. To manage the growth and to keep the trees relatively small, pruning during the dormant period is also used.

During the early stage of establishment (first 3-4 years), walnut trees do not compete very well with other vegetation. So, the ground at the planting site of the walnut could be covered with less competitive low staying ground covering plants, in order to reduce the weed competition. Some species that can be used as cover plants are; Kentucky blue grass (*Poa pratensis*), Bermuda grass (*Cynodon dactylon*) and red clover (*Trifolium pratense*) [124]. Moreover, the association of walnut with the common hazel (*Corylus avellana L*.) will reduce the weed competition for the walnut tree because hazelnut covers the ground fast [122]. Other studies have also shown that the architecture (height, width and estimated volume) of the common hazel and Japanese silverberry (*Elaeagnus umbellata*), had a significant positive effect on walnut height. This means that the presence and association between those species was beneficial for the walnut tree [123]. Further research has to be done on this specific situation on the campus to corroborate the positive effect of this association.

Common Hazel (*Corylus avellana L*.):

This shrub is native to Europe and is also present in North Africa and western Asia. It is a multi-stemmed shrub and can grow from 1 to 6 m tall. Common Hazel flowers blossom in the early spring before the leaves emerge and the fruit is ripen in September [114].

We would like to include this species in the fruit garden because it rapidly grows and reduces the weed competition and because it tolerates strong winds and urban pollution, thus it can be used as shelter from strong winds [114], [122]. However, the rapid growth can also restrict management, like pruning and it is therefore important to plan the location of the species well to not disturb the management [122].

Regarding soil condition, Common Hazel tolerates wet condition but not waterlogged soils [114]. According to Loewe V. et al, 2013, the association between Cherry trees and the Chilean hazelnut (*Gevuina avellana*) decreases the incidence of the Cherry slugworm (the larvae of the pear slug

sawfly *Caliroa cerasi L.)* a destructive pest that feed on the surface of leaves, compared with pure cherry plantations. However, more studies have to be done to know if it is possible to see an decrease in some insects pests with the association of Cherry and common hazel in the environmental conditions of the WUR campus [118].

Pear (*Pyrus spp*):

The pears belong to the plant family of the Rosaceae. Some species are edible, whereas others are grown as ornamental plants. It is indigenous to coastal and slightly temperate areas of Western Europe, north Africa and eastern Asia. Three species of pears are well known to produce edible fruit, the European pear (*Pyrus communis* subsp. c*ommunis),* the Chinese white pear (*Pyrus bretschneideri),* and the Asian or apple pear (*Pyrus pyrifolia).* Each of these three species has thousands of cultivars. The European pear or common pear is a species of pear indigenous to central and eastern Europe and southwest Asia [125].

Pollination and contribution to diversity

Including pears in the fruit garden is necessary to better sustain in the food supply of bees, because honeybees prefer to gather pollen on pear flowers and nectar on apple trees [126]. Faoro and Orth, 2011 realized a study about the nectar production of the pear species *Pyrus pyrifolia* and stated that due to the low total soluble solids (TSS) in the nectar, the attraction of the insect pollinators is probably mainly through its pollen resource [127]. They attributed the lack of nectar in the flowers with the incidence of moderate winds and little rainfall. Moreover, pears needs to be cultivated with other pear cultivars because the cross pollination is a common pollination system in pears using insects, like bees, which are the major pollen dispersal agents [128]. Moreover, some species of butterflies are attracted by the blossoms of the pears.

Moreover, some studies show that the pear trees can function as food source and shelter for birds, and ants that are attracted by the pears, which in turn function as a food source for birds [129]. We will therefore include pears because a garden design that contributes to plant diversity will increase the resources for many animal communities [130].

Soils and Growth

Pear trees should be planted in full sun and should be provided with sufficient air circulation. Soil should be well-drained, but still moist and can consist of loamy, clay or sand and should be slightly acidic with pH 6.4 to 6.8. Thus, pears could therefore also be located in the higher parts of the campus, or on heightened ground like described before. Planting density is one of the most influencing factors for pear production in gardens. Many studies show that increased plant density results in higher and earlier production of pears and because of higher density, the canopy becomes more closed and causes greater light interception compared to low plant density [131, 132].

Further ideas for the fruit garden

More study has to be done on how these fruit trees would help to increase the attraction of birds and small animals into the campus and corroborate the result found in other studies in this specific environment.

We also consider doing a more in depth soil analysis test, which will help to know the current amount of nutrients and some chemical characteristics of the soils on the campus.

In order to decrease the amount of pests, biological control can be used and some of the following principles can be followed [130]:

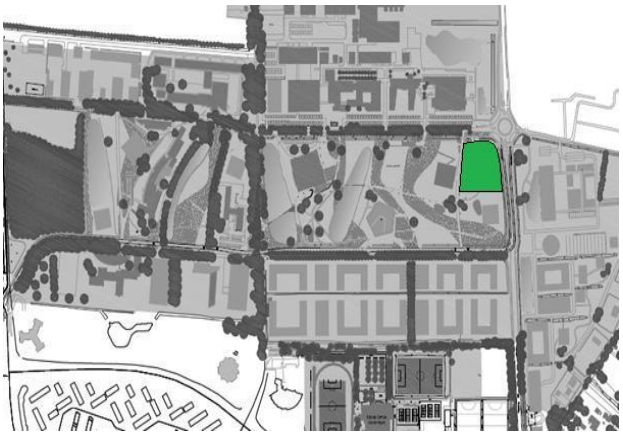
- Exclude tree species that can be hosts for pests and quarantine diseases
- Provide natural enemies of pests with various habitats and resources like shelters and hibernation sites by including hollow stems of herbaceous plants, bark fissures, evergreen leaves of bushes or tree species. Also, incorporate different herbaceous species to provide food such as pollen, nectar, alternate preys or hosts.
- Organise resources that stay year long, in order to maintain and multiply beneficial arthropods.

  Furthermore, this fruit garden can be used as a first approach on how to include some of the knowledge obtained by the students in Wageningen campus and put this in practice to create a self-reliant fruit garden and help to increase the aesthetical view of the Campus and satisfy stakeholders.

Summarizing, this fruit garden can be made relatively self-reliant, but to be able to make this possible it is necessary to do more research on species, which could help to improve the pest and disease management and weed control, which species are good supplies of food and shelter for animals and which species should be placed where to satisfy the nutrient demand, finally interactions between others species and other factors should be looked at to improve on the growth and vigour of the plants.

Insect garden

Insects are perhaps the most important parts of an ecosystem because they can be highly beneficial in many different ways. They can enhance the plant diversity through pollination and biological control of pests by natural enemies, they can function as a food source for amphibia, birds, reptiles and rodents and therefore they help in the conservation of animal diversity. Some insects like butterflies, dragonflies, damselflies etc. are known for their aesthetical value to parks and ponds. Furthermore, many beneficial insects are red listed which need to be conserved, therefore to enhance the biodiversity of the WUR campus, as well as make the campus more natural looking, it is a good idea to establish an insect garden.



Figures 50. Map of the campus indicating place of importance in green

The proposed flower meadow strips and fruit garden on the campus will benefit from the increasing number of pollinating insects from the garden. The plants in these proposed areas are highly dependent of insects for pollination and also insect pests infesting the garden can be managed by biological control by natural enemies like parasitoids and predators. We propose to place the insect garden in the north-east corner of the main campus ground (figure 50). In this way it is close to the Lumen garden and it can function more as one big area for insects. At the other end we propose to let the garden smoothly change into the proposed wetland area, which will provide the water needed for some insects [133].

Before starting the design of an insect garden in Wageningen UR campus, it is necessary to know which insects are beneficial for this garden and what the suitable plant species are for attracting insects. Here we will provide a list with beneficial insects and the practices to create the right environment for these species.

Beneficial insect groups for in the garden

- Butterflies (*Lepidoptera*)
- Dragonflies and Damselflies (*Odonata*)
- Lacewings (*Neuroptera*)
- Solitary bees, Honeybees, Bumblebees etc. (*Apidae*)
- True bugs (*Hemiptera*)
- Parasitic wasps (*Apocrita*)
- Beetles (*Coleoptera*)
- Flies (*Diptera*)

Practices

To create a nice and well-functioning insect garden you need some practices. These practices include picking the right plant species and creating a suitable habitat for these different insect species. Below a description of these practices is given.

Host plants for insect attraction

Suitable food plants in the garden help to attract many kinds of insects by providing food as well as shelter. For example, Hop (*Humulus lupulus*) attracts a number of butterfly and moth species like for instance the Comma/angle wing (*Polygonia c-album*) or the Red Admiral (*Vanessa atalanta*) [134]. These species have already been spotted in the surrounding areas, but not yet on the campus [26]. Planting these plant species will attract the butterfly species to the campus. In this way a garden can be created to attract species from the surrounding areas or species which are endangered in the Netherland to help them recover. For all the different host plants see appendix 14.

Bug boxes

A bug box (see figure 51) is a manmade structure made up of various natural materials and they exist in various different sizes and shapes, to meet the needs of each specific insect. Bug boxes offer comfortable and safe habitats for different groups of insects for hiding and hibernation, especially for solitary honeybees, ladybirds, lacewings, beetles and dragonflies. These species are significant, as larvae of lacewings and ladybirds and adults of ladybirds devour insect pests like aphids. The following points of attention should be taken into account regarding bug box in the garden:

Figure 51. Example of a combination of bug boxes

- The boxes should be placed in such a way that some of it will face the sun and rest of it will catch the shade under a tree or near a hedge.
- Small bug boxes can be hanged at tree trunks or branches, at walls and other structures.
- Attractants can be put in bug boxes to promote lacewings, ladybirds and other beneficial insects.
- Putting dead wood inside some bug boxes can be essential for; larvae of wood-boring beetles, because they need fungi grown on the dead wood to break down the material for them to eat. But also woodlice and centipedes are able to find shelter under the bark of the dead wood.
- Placing different kinds of hollow stems like old bamboo canes or drilled wood blocks in bug boxes, provides shelter for solitary bees. These holes should be of different diameters to provide shelter for different species.
- Keeping straw and hay inside the box which provides opportunities to insects to burrow in and sites for hibernation.
- Putting dry leaves inside the box provide habitats for a variety of invertebrates and also mimic the garbage on forest ground.
- Loose bark and decaying wood in bug box provide loitering place for spiders, beetles, centipedes and woodlice.

- Placing some stones and tiles at the centre of the bug box to provide damp environment for frogs and toads.
- Putting some dry sticks and leaves inside the bug box provides suitable habitats to larval and adult ladybirds for hibernation.
- Queen bumblebees in spring search for sites to make nests and upturned flower pots are ideal as nesting places, thus could be placed inside the bug box.
- The bug box could be integrated in the surroundings, by making it more natural looking.

Stone walls

Properly maintained stone walls without using mortar are a valuable habitat for wildlife. The corners and crevices created in the wall can hide several species of beetles, woodlice, springtails, spiders, ants, bees and butterflies. At first the new wall is colonized by lichens. Then soil accumulates where mosses, pennywort and fern grow and provide mini-habitats for insects and other invertebrates. It also functions as a corridor for small mammals to move from one place to another. Figure 52 shows a nice example of a stone wall on which plants are able to grow, with shelters for insects. While making stone walls, following facts should be considered [135]:

Figure 52. Example of a dry stone wall.

- Located in shady, yet moist conditions.
- More stable with wider base and tapering as it goes up.
- Larger stones at the bottom, and if needed alongside the base smaller stones can be placed.
- Smaller stones in the middle of the wall.
- The tops of the walls filled with diverse varieties of plants that can tolerate dryness. For example, sempervivum and sedum.
- Creating different types of insect habitats by inserting old books and such things. Some species of insects like wasps use the paper pulps to build nests

Beetle bank

A beetle bank is a strip of grasses and perennial plants within a garden or farmland that provides habitat for many beneficial insects, birds and other animals that prey on insect pests (see figure 53). Thus, it plays an important role in biological control of insect pests. The following plants are commonly used for the construction of a beetle bank [136]:

- Sunflower *(Helianthus annuus)*
- Faba bean *(Vicia faba)*
- Cornflower (*Centaurea cyanus)*
- Coriander (Coriandrum sativum)
- Borage/Starflower (Borago officinalis)
- Feather grass (*Stipa*)

To control the amount of aphids in the beetle bank the following plants can be used [136]:

- Creeping bentgrass (*Agrostis stolonifera)*
- Cock's-foot (*Dactylis Glomerata)*
- Meadow soft grass (*Holcus lanatus)*
- Perennial ryegrass (*Lolium perenne)*

Figures 53. Example of a beetle bank

Pond

Creating a pond in the garden will bring more diversity in the garden landscape. The pond will be suitable habitats for insects, amphibia, and reptiles. It will also be a drinking and bathing place for birds and small mammals. Besides this, the ponds water will be medium for oviposition and larval and pupal development of insects such as dragonflies and damselflies [133]. In turn these insects play an important role in the food supply of other animals. Moreover, planting around the pond would provide resting places for insects. Planting suitable wetland plants on slopes can provide much shelter as well as food for wildlife. Ideas of creating more wetland areas have been suggested in the next section of this report.

Maintenance of the insect garden

Regular monitoring of the insect garden is necessary to keep the garden sustainable and the following actions could be taken for proper maintenance:

- Annual plants can be changed every year/season
- Although pests in garden ecosystems are used as food by natural enemies, the maximum level of plant damage must be decided beforehand.
- Reducing or eliminating the use of chemical pesticides because they kill beneficial insects as well as heap up in the food chain.
- Monitoring and treatment of plant diseases
- Plantation should be done based on the season for season specific insects

Ponds and wetland areas on the WUR campus

The WUR campus lies in a low area between two natural areas of the Veluwe and Utrechtse Heuvelrug. Because these neighbouring areas are situated higher, it is causing seepage (kwel) into the soils of the campus, causing the area to have a high groundwater table. Therefore the area has a very wet ground, sometimes even floodings can occur. To prevent this from happening, open water areas should be kept, to hold some of the groundwater. Because of this amount of water, the campus can function as a wetland area.
Already many water birds are seen in the ponds, however at this moment not much shelter and food is present for wildlife such as specific wetland birds, insects, amphibia and small mammals.

Ponds

Vegetation on the water edges and in open water can increase the corridor function and will provide shelters and food for animals on the campus. However, extra vegetation in the water is not wanted by the WUR, because it can cause an obstruction to the continuous flow of water from the ponds to the water system. This system is interconnected and needs to be kept open for optimal functioning (Personal communication Elike Weinheimer). However, we think it is possible to both keep the water system open and at the same time have a more rich and natural pond vegetation.
In this case, of course there has to be maintenance of the water vegetation, but optimally this should be kept minimal. Thus, no fast growing or invasive plant species should be planted. If extra vegetation is planted, those plant species should be sought for, that requires the least maintenance and will not cause any problems for the natural water flow.

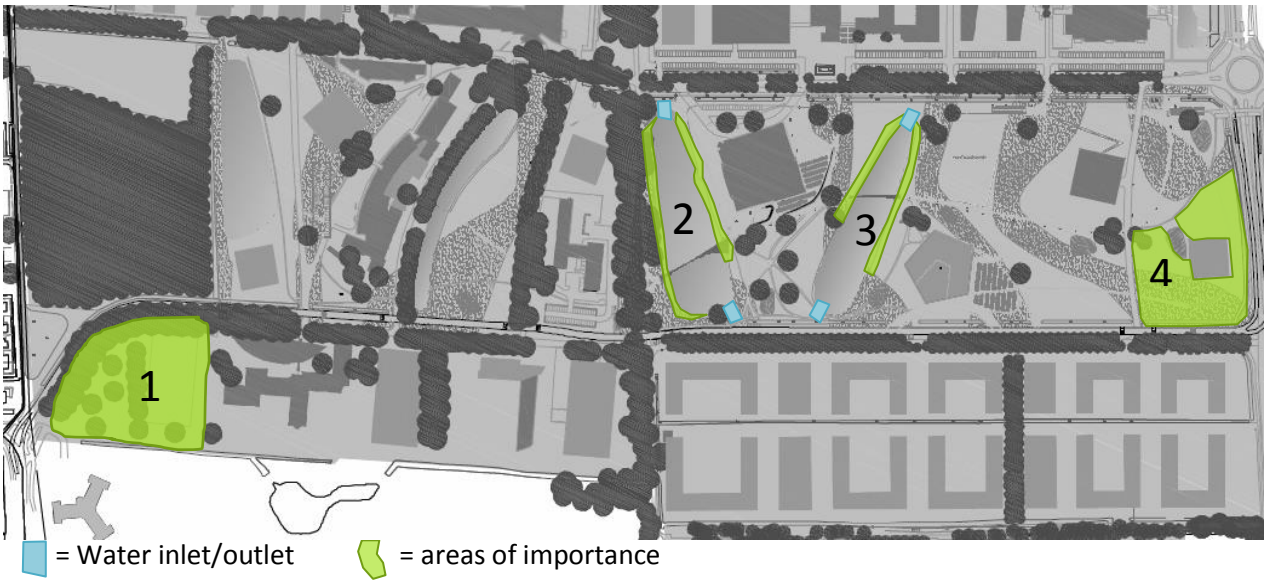


Figure 54. Map of part of the WUR campus. Important areas are numbered & indicated in green

Figure 54 shows part of the map of the WUR campus. Numbers 2 and 3 represent the western and eastern ponds near the Forum building. The green areas surrounding these ponds indicate where increased vegetation could be placed.

For the western pond, an increase in natural area would result in less view on the Bornsesteeg from the Forum field. This gives a more green impression. In this case the vegetation should be kept low or absent near the water in- and outlets, whereas the other vegetation could remain higher.

The east pond should be kept more open to maintain a nice view on the rest of the campus park in the east. To still increase the natural looks and value for wildlife, vegetation can still be included but should, on water borders and in the water, be kept low by maintaining regularly or by planting low growing plant species.
For both ponds it is necessary to have no vegetation near the water in and outlets, for at least several meters, to ensure no blocking of the water flow can occur (personal communication Elike Wijnheijmer). Also, low or no water vegetation is wanted at those areas next to the ponds where there are sitting places, such as on the fields south of Forum. This ensures that students and staff sitting there will still be able to look into the ponds.

Natural wetland area

Another idea is to create more natural and somewhat wilder areas on the campus. Here we have chosen for wetland type area, with a high biodiversity and a nice relaxing atmosphere, where people can enjoy walking during free time and lunch breaks. This could become the habitat and shelter to many different animal species. There are many types of wetlands, but the main characteristics of a wetland are that there is water present most of the year near the surface, that it contains many plants that are adapted to live in wet conditions and that it has a water filled soil [137]. Although there are many definitions for every type of wetland in every other country, in general the types of wetlands that could probably be realised on the campus are freshwater marshlands or (vernal) pools [138].
Historically, much of the Netherlands consisted of wetlands, such as marshlands and fens. Nowadays wetlands are still an important part of the Netherlands as they play a large role for our wildlife and in our natural areas. Creating a wetland area therefore also integrates history of the Netherlands and its natural values. Wetlands have a high esthetical and cultural historical value for people, they look beautiful and can be a good place for relaxation. However, at the same time they are also somewhat wilder. Therefore, they have one of the largest diversity of plants and animal wildlife. Not only is a marshland area a great place for wildlife, but it also brings more diversity in the landscape. More diversity in the terrain also means more animal and plant species. Insects, amphibia, reptiles, birds and small mammals are able to thrive in such a marshland region. It can function as a drinking place for mammals, amphibia can find food and shelter in between the plants and water, and deposit their eggs on aquatic plants. Also, insects such as dragonflies can deposit their eggs and their larvae can develop in the water [133]. In turn these insects play an important role in the food supply of other animals. Thus, a marshland or pool area will contribute to a total increase in diversity of natural life on the WUR campus. The idea of an insect garden is described in another module plan. According to our knowledge, it could be a good idea to place the wetland area close to this insect garden, because both would benefit from each other. Also aesthetically, the two areas can be connection in a harmonious way.

Some areas on the WUR campus are more suitable than others for creating a wetland area. As indicated in figure 54, area 1 (the field north of Dijkgraaf, south of the Dassenbos) and area 4 (area north of Campina, southeast of Atlas) are two places that could be used in creating a wetland. Area 1 can be changed into a more diverse wild looking area since it is not used a lot by students or employees, but it does however contribute a lot to the natural diversity and animal wildlife on the campus. Also it would ensure a better connection between the Blauwe Bergen and the Dassenbos. It could be left more natural with no maintenance and in this way made more self-reliant. Eventually it

could also be used in research into certain topics. The other suitable area 4, north of Campina is already partly waterlogged, mainly due to the fact that the groundwater level is very high. Therefore, already almost by itself, this area could be considered a wetland. Because it is easier (and therefore cheaper) to enlarge the already existing wet system and expand upon this natural wetland area, the possibility that the plan will work is high.
Up until now, there are no definitive plans for these areas in which a wetland could be realised. Area 1 is left as open grassland and looks bare until today. In area 4 however, there might be an upcoming plan to build a building, which for now is called the "Auditorium" [1](personal communication Elike Wijnheijmer). If this plan is finalised and really continues, there are still possibilities to use the available area 4 as temporary wetland using the temporary nature guidelines, as set up by the ministry of agriculture, nature and food-quality (LNV) [139]. This could then at least temporarily ensure an enlarged natural area and corridor for animal species and increased aesthetics.
Another suggestion is that, because the area will not be used in total for the building, the available surroundings around the auditorium in area 4 could still be transformed into wetland. In this case, either a smaller area next to the building or the whole surrounding area could be used and wooden bridges or paths could be made as main walking roads, to connect the building. It might be a good idea to integrate a plan for a wetland area before any other alternative plans arise in the indicated areas.
Several aspects are important when creating a wetland environment, such as a pool or marshland area, that should also be able to function as a habitat for amphibia, insects and birds [140]. The most important aspects that should be taken into consideration are listed below.

- Enough plant material should be present for animals to deposit their eggs and find shelter.
- Water slopes should not be too steep, low degree slopes are easier to use by all kinds of animals. Amphibia especially prefer low watersides with slight slopes, because it makes it easy for them to climb in and out of the water, but also because more plants can grow on a low sloping bank, causing these banks to have more shelter areas.
- The water should contain enough nutrients so that plants and algae are able to grow and function as a food supply for wildlife.
- At least 50% of the area should consist of open water, so some maintenance is required if the water area is covered by plant material.
- Enough light should be available to reach the bottom and therefore the area must not be covered by swamp plants, or fast growing plants.
- The area should not be too acidic or alkaline (around a pH of 6-8).
- No big fish should be kept in the waters, they will eat any algae-feeders, which form most of the life in the marshlands.
- Slow flowing water should be present, since a fast water flow will disturb the natural growth of vegetation and the sheltering animals.
- Surrounding land habitat should contain hiding places such as trees, dead wood material, or rocks.

Animal species in surrounding areas of the campus that could use this wetland area, should be taken into account. The area could be adjusted to fit their needs, to enlarge the possibility that these species will inhabit this new wet area. Some of the species that are found in the surrounding region of the WUR campus, such as the Binnenveld and the Uiterwaarden, are listed below.

- European common frog (*Rana temporaria*), open waterbanks and enough light availability is needed for this species.
- Moor frog (*Rana arvalis*), occurs almost everywhere throughout the Netherlands and is also a good candidate for inhabiting a marshland area on the campus [141].
- Green frog species complex (*Pelophylax*):
  pool frog (*Pelophylax lessonae*), Marshfrog (*Pelophylax ridibundus*) and their hybrid the edible frog (*Pelophylax klepton esculentus*) are common green frog species that can live in most wet areas throughout the Netherlands [142].
- Common toad (*Bufo bufo*), is the most common toad in the Netherlands.
- Natterjack toad (*Bufo calamita*) is found in many places in the Netherlands, such as the uiterwaarden. It needs shallow pools and water for its survival in order to warm up quickly. Again this is a reason why sloping watersides are preferred above steep banks.
- Smooth newt (*Lissotriton vulgaris*)
- Alpine newt (*Triturus alpestris*)
- Northern crested news (*Triturus cristatus*)
- Grass snake (Natrix natrix)
- Within the insect orders, the *Odonata*, to which both the dragonflies and damselflies belong, are dependent on water for their reproduction and growth of larvae.

Attention should be paid to what plants are used in this plan and several things should be kept in mind. Plants that are placed in the middle of the water should be slow growing, stay low in height and they should also be capable of handling very wet conditions, as they will probably stay mostly submersed. All the plants together should form an adequate environment for the species living in the surrounding areas of the campus. The vegetation should not grow too fast, that it will cover the open water area quickly and thus maintenance would be required multiple times a year. A maximum maintenance frequency of only once or twice a year would be preferable. The plant species should be easily kept under control so it will not take too much man-hour to maintain it. Two examples plants that look nice to keep in a marshland area, but have a high maintenance are, the Water Soldier *(Stratiotes aloides)* and the European white waterlily (*Nymphaea alba,* see figure 55*).* These two species look very nice and suitable but have excessive growth, so they might not be the perfect species to use in a small marshland area, because they quickly fill an open water area if not regularly maintained. These are good examples of why it is important to take a better look at what type of plant species should be used in the area.

Figure 55. Pictures of top, S. aloides and bottom, N. alba

Furthermore, species of plants that will be used should be capable of handling very wet conditions and several plant species that stay partly or totally submerged are also good for aquatic fauna. Water border vegetation that can be used, can consist of larger plants like reeds and grass-like species and plants that are not completely submersed in water [143, 144] and plants that stay smaller, which can be used as mid-water plants.
Many Carex species such as: *Carex pseudocyperus, C. paniculata, C. riparia, C. acutiformis, C, rostrata,*

C. vesicaria,C. otrubae are hardy plants that are suitable for water borders, but are also relatively large. Other somewhat smaller species that can be planted near the water borders are:

- *Typha latifolia and angustifolia* (1-2.5 & 1-3m)
- *Glyceria maxima and G. fluitans* (0.9-2m, 0.45-1.2m)
- *Sparganium erectum* (0.3-1.8m)
- *Eleocharis palustris* (0.1-0.9m)
- *Mentha aquatica* (0.3-0.9m)
- *Juncus effusus* (0.2-1.4m)
- *Phalaris arundinacea* (0.5-2m)

Furthermore, plant species that can be grown in the middle of the water should remain somewhat smaller, examples of hardy plants that can be used are:

- *Nymphoides peltata (0.9-1.5m stems stay underwater, leaves and flowers not)* [89]
- *Eleocharis acicularis (max 0.2m)* [144]
- *Caltha palustris (0.15-0.5m, helophyte)* [144]
- *Sparganium emersum (0.2-0.6m, hydrophyte)* [144]
- *Berula erecta (0.3-0.6m)* [144]
- *Myosotis scorpioides (0.15-0.5m, rarely max 1 m)* [144, 145]

Diversity in the area can be created by incorporating both very wet and drier areas. This can be done in a marshy pond by having more closed vegetation borders and more open ones to enable animals to sunbathe and get warmth, also to find shelter from other animals and humans. Also dead wood or larger rocks can be added on slopes, to contribute to shelter and food for animals (see box1). Furthermore, there could be both high and low vegetation, with an increase in vegetation height on water border and surroundings, compared to in the water. Another possibility is to create a small wooden crossing like the one over the pond at the Lumen garden. Figure 56 shows an example sketch of a small pool, or marshland in area 4.

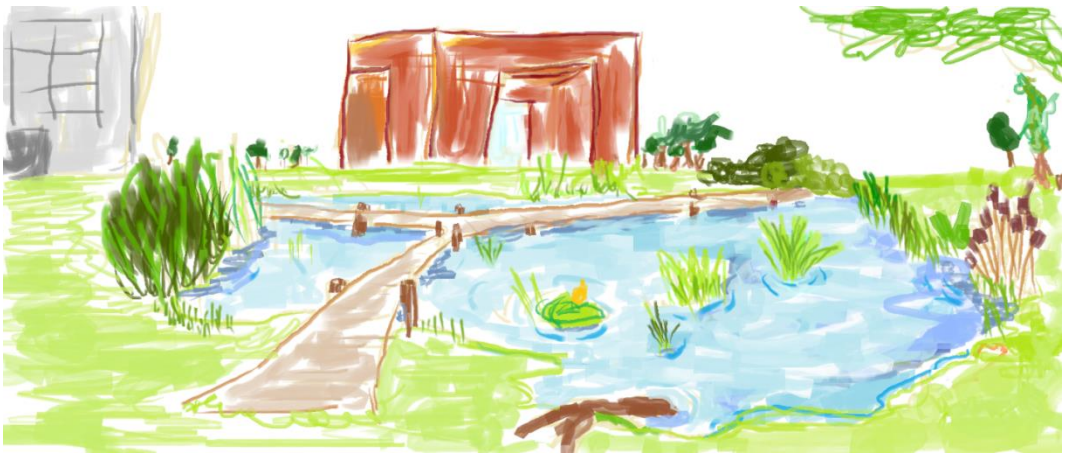


Figure 56. Example sketch of a marshland/pool area with the Orion and Forum in background

Box 1. Dead wood contributes to natural diversity

Dead wood make an important contribution to the natural diversity in an area and can be divided into two types: lying and standing [5, 6]. Lying wood may be found in the Dassenbos, but could also be incorporated into the wetland area. They provide shelter for small mammals, amphibia, birds and reptiles. Because of decomposition, the microclimate in a log is more humid than outside the log. This humid microclimate makes it a good shelter for amphibia, since they need to keep their skin humid [5, 6]. Insects use the logs as a habitat for egg laying and feeding and they also form a good food source for amphibia, birds and small mammals [5]. Therefore, lying pieces of wood contribute to a more diverse area by giving shelter and providing food.

It is not plausible to randomly distribute pieces of wood across the campus. However, we would like to incorporate lying wood into marshland-like areas where they might give the fullest benefits to the animals inhabiting these areas. Standing wood might be found in the Dassenbos. They are important as nesting places for birds and small mammals, such as squirrels and bats and the great spotted woodpecker, which is currently present.

Below, example figures are shown which include several aspects of wetland areas that could be incorporated. Each figure contains an aspect that could be used.

Figure 57. Impression water banks with in slight inclines

Figure 58. Impression water banks with high vegetation

Figure 57, shows water plants such as lily's, it also contains low water borders and vegetation on slopes with slight inclines that are preferred by amphibia.

Figure 58 shows higher water plants in a marshland area. These should be growing interspersed throughout the edges of the open water. Not all borders should be covered completely.

Figure 59, shows wooden walking boards that could be created to cross the marshland or pond area, in almost the same way as the small bridge crossing the pond behind the Lumen building.

Figure 60 and 61 shows pieces of dead wood and logs in the water, this can be used as dry areas and shelter opportunities for amphibia and insects in and near the water.

Figure 59. Impression of wooden walking boards.

Figure 60. Impression of logs in the water with vegetation on it

Figure 61. Impression of logs in the water

Conclusion

This report focussed on providing modular plans for improving the aesthetics and the biodiversity of the Wageningen UR campus and combined these two aspects into the concept of natural diversity.
As described in the paragraphs “current situation” and “surrounding areas” in the introduction, the campus is inhabited by a wide variety of animal and plant species. Large parts of the species which live on the campus also live in the areas surrounding the campus, and vice versa. This leads us to conclude that the Wageningen UR campus is already a functioning part of the surrounding natural areas. However, this functioning can be improved, for instance by completing the ecological corridor which is planned on the campus, which will improve the connection between the Veluwe and the Utrechtse Heuvelrug if it works as planned. Changes on the campus will have the largest chance of being accepted if they have a positive impact and are supported by the stakeholders of the campus.
Various stakeholders of the WUR campus were identified: students and employees of the WUR, the head and facility management of Wageningen University and Research Centre itself, Wageningen municipality, NIOO-KNAW, Hogeschool STOAS-Vilentum and Friesland Campina Innovation centre Wageningen.
The main interests of these stakeholders were:

- Wageningen UR students and employees [Bresser, 2013 #6]
    - Would like a campus with more trees.
    - Would like more facilities (including supermarket, nursery, café).
    - Would like more private places to sit.
    - Would like an outside meeting area.
    - Would like a less barren and nicer more natural appearance of the campus.
- Wageningen University and Research Centre (personal communication Ad van der Have and ElikeWijnheijmer)
    - Would like to maintain an open view, e.g. in between the three big buildings (Atlas, Forum and Orion) and through the wooded bank.
    - Would like to maintain a functional area on the campus, on multiple places such as the event field.
    - Would like to see a wilder area developed between Dijkgraaf and the Dassenbos.
- Wageningen Municipality (personal communication with Michiel Uitdehaag)
    - Would like to see the campus integrated more into the surrounding landscapes.
    - Would like to see the ecological corridor across the Wageningen UR campus completed.
- NIOO/KNAW (personal communication Louise Vet)
    - Would like to see more biodiversity at the campus
        - Native species of bushes.
        - Hedgerows to improve quality of life for insects, birds and small mammals.
    - Would like to see that the WUR incorporates its knowledge expertise and that of its students more in the campus, to show to the outside world what they stand for.
    - Would like to see an area that includes knowledge in the form of permaculture
    - Would like to see the campus include more sustainable ways of using architecture and landscape, such as more sustainable energy use, solar panels, green roofs etc.

Although multiple attempts have been made to get into contact with the other stakeholders, they were unable or unwilling to answer our questions regarding the natural diversity of the Wageningen UR campus, therefore their opinions have not been taken into account.

Several of the stakeholder interests have not been incorporated into the modular plans of this project:

- *More facilities*. The facilities that were requested are already planned to be incorporated in the new building of the Campus Plaza.
- *An area of permaculture*. This project describes plans that can be executed within 5 years. It will take approximately 30 years to develop a functioning permaculture. Since this exceeds out time limit, this report does not take permaculture into account. A short description of possible positive interactions between plants is solely given in the plan of the fruit garden.

Using the known preferences of stakeholders and our own initiatives and ideas, the following modular plans have been devised:

- *Light regime*. The life quality of lots of animals can be improved by changing the streetlights on the campus. Bats and birds both respond differently to different lights and the light regime should be considered separately for each situation on the campus. Changing the light regime is in accordance with the wishes of NIOO/KNAW.
- *Sitting places, niches and moveable nature*. More sitting places and separate niches are wanted by students, to create a more social environment where people can gather and chat in spare time. We proposed to create more sitting places and (wind sheltered) niches. Another plan was to create moveable nature, it is possible to create more natural environments even in large, open areas that are needed only a couple of times each year. This can be done by moving nature onto them when it is not needed for them to be open. In this way, the natural appearance of the campus is improved, while there are no adverse effects on the functioning of these areas, since they will still be available when needed. This will satisfy desires of both Wageningen students and employees and Wageningen University and Research Centre.
- *Meeting area and amphitheatre*. Situated to the east of the Orion, an amphitheatre would provide a welcome meeting place for the users of the campus on dry and warm days. Also would it function as an available open air lecture area as well as integrate more cultural aspects on the campus ground. The amphitheatre could be integrated in the surroundings by planting fruit trees and plants around the outside of the slopes. Integrating a structure such as this amphitheatre in the campus would satisfy the desire of Wageningen UR students and employees.
- *Wooded bank.* To get a more open look on the campus between area C and D, we proposed to change parts of the wooded bank, making them more open for view and more closed on those areas where only buildings can be seen on the other side. These would otherwise only be an obstruction to the natural appearance.
- *Integration of buildings in the landscape*. Buildings can be better integrated into the landscape by planting plants or trees close to them. This can be done in several ways, such as including:
    - Climbing plants on the side of buildings
    - Plants in the stone hedges around bicycle parking areas around Forum and Orion

    - More trees on the parking lots

  We think integrating the buildings into the landscape will result in improved aesthetics of the campus.
- *Artificial nesting sites*. To provide more shelters and to attract more species of animals in the campus some sorts of artificial potential nesting sites can be created. Installation of bird and bat boxes on the tree trunks and building walls will provide alternative and secured roosting sites shelter to some species of birds like owls, common swifts, starling and sparrows and also species of bats. Artificial nesting boxes can also be created for hedgehogs, solitary bees and bumble bees. Moreover, nesting sites like floating platforms and cylinders can be made for aquatic birds.
- *Green connections*. This project proposes to increase the ecological connectivity of several areas across the campus. These areas are:
    - Between the natural areas of the Blauwe Bergen and the Dassenbos
    - Between the north of the Bongerd sport centre and the Orion building
    - Connection between the east and the west across the campus

  Improving the green connectivity can be done by planting smaller plants, bushes, trees or hedgerows between the two areas, and by improving chances for land-dwelling animals to cross the roads. This plan suits the desires of Wageningen municipality and NIOO/KNAW.
- *Flower meadow strips*. There are several sites on the campus where strips of flower meadows can be integrated. These strips can improve the aesthetics of the campus, provide niches for people to sit in and can help to blend in more naturally and improve the connectivity between stepping stones. These flower strips fit the desires of Wageningen UR students and employees, Wageningen municipality and NIOO/KNAW
- *Fruit garden*. A likely location for a fruit garden is in the surrounding area of the Amphitheatre. It will increase natural diversity of the campus and will provide new places for nesting, shelter and food recourses for small animals, bird and insects. Additionally, it will increase the aesthetical view of the campus providing beautiful and colourful blossom flowers. It will also create a nice place to walk or sit for campus users. The fruit garden could be used as an experimental field for biological control of insects and diseases or other related studies. Furthermore, it would be possibly to incorporate knowledge obtained at the University into the fruit garden. This fruit garden would be in line with wishes from Wageningen UR students and employees, and NIOO/KNAW.
- *Insect garden*. An insect garden, for instance located to the north-east of Atlas, could provide several benefits. It will increase the amount of species of plants on the campus, and invite more insects to use the campus grounds as foraging or living area. If properly constructed, the garden will attract insects, increase the pollination success of flowers in the campus, increase the biological control of pests of plants by parasitism, enhance the campus's aesthetics, provide places for walking and enhance the ecological corridor function. This is in accordance to the desires of Wageningen UR students and employees, Wageningen municipality and NIOO/KNAW.
- *Wetland areas*. The wet state of the grounds of the Wageningen UR campus naturally lends itself for the construction of wetland areas. The area east of Atlas, and the area between Dijkgraaf and the Dassenbos are especially suited for this type of environment, due to their wet state and the lack of long-term building plans. These areas will provide an increase in biodiversity, could provide an increase in ecological corridor functioning and private places to

meet other people, thus satisfying desires of Wageningen UR students its employees, Wageningen University and Research Centre, Wageningen municipality and NIOO/KNAW.

Recommendations

This report is not a complete manual towards making the Wageningen UR campus a better place in the views of all involved, however it does contribute to gaining more knowledge on the possible solutions to making our campus a better environment for its stakeholders. The main focus of this project was to provide plans for improving the natural diversity at the Wageningen UR campus, but unfortunately not all necessary research needed for accomplishing all plans has been executed due to time limitation. During our ACT course there was no time for field work, therefore we can only propose which research is the most wanted. The following is probably the most pressing to be resolved:

The soil of the Wageningen campus is not settled yet (personal communication Andre van Amstel), therefore more knowledge should be gained and an analysis could be done on those factors that influence plant-growth and establishment, such as soil quality, water quality and light quality. This should be done prior to incorporation of plants and trees on the campus.

Another recommendations is to gain more knowledge about different species and their connections. In this way you will create a better self-reliant area so less maintenance is required.

There are plenty of research possibilities hidden in these new projects.

For instance, it would be interesting to perform a research about the corridor function of the stepping stones on the campus. If the stepping stones are realised before the higher vegetation between them is realised, a research could look into the effects of connecting vegetation between stepping stones in an area which is intensively used by humans.

Also, research can be done in the fruit garden. Experiments with biological control of pests can be done, although disturbance of the experimental area by the campus users should be taken into consideration.

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Appendices

Appendix 1: Species first inventarisation

Overview of species found in research done by Alterra in 2004 [11]

Bats	
Nathusius' pipistrelle	*Pipistrellus nathusii*
Serotine bat	*Eptesicus serotinus*
Common noctule	*Nyctalus noctula*
Daubentons bat	*Myotis daubentonii*
Common long-eared bat	*Plecotus auritus*

Other mammals	
Common shrew	*Sorex araneus*
Greater white-toothed shrew	*Crocidura russula*
European mole	*Talpa europaea*
Field vole	*Microtus agrestis*
Common vole	*Microtus arvalis*
Bank vole	*Myodes glareolus*
Wood mouse	*Apodemus sylvaticus*
Harvest mouse	*Micromys minutus*
Brown rat	*Rattus norvegicus*
Red squirrel	*Sciurus vulgaris*
European polecat	*Mustela putorius*

Birds	
Eurasian nuthatch	*Sitta europaea*
Short-toed treecreeper	*Certhia brachydactyla*
Eurasian magpie	*Pica pica*
Willow warbler	*Phylloscopus trochilus*
Eurasian jay	*Garrulus glandarius*
Marsh tit	*Poecile palustris*
Common whitethroat	*Sylvia communis*
Europian greenfinch	*Chloris chloris*
Dunnock	*Prunella modularis*
Stock dove	*Columba oenas*
Common wood pigeon	*Columba palumbus*
Western jackdaw	*Corvus monedula*
Great tit	*Parus major*
Eurasian coot	*Fulica atra*
Common blackbird	*merula*
Blue tit	*Cyanistes caeruleus*
Long-tailed tit	*Aegithalos caudatus*
Common chiffchaff	*Phylloscopus collybita*
Garden warbler	*Sylvia borin*
Eurasian collared dove	*Streptopelia decaocto*

Common chaffinch	*Fringilla coelebs*
Common moorhen	*Gallinula chloropus*
Mallard	*Anas platyrhynchos*
Eurasian wren	*Iodytes troglodytes*
White wagtail	*Motacilla alba*
Song thrush	*Turdus philomelos*
Carrion crowe	*Corvus corone*
Eurasian blackcap	*Sylvia atricapilla*

Grey Heron	Ardea cinerea
Goldcrest	Regulus regulus
Grey Wagtail	Motacilla cinerea
Brambling	Fringilla montifringilla
Northern Lapwing	Vanellus vanellus
Common Linnet	Carduelis cannabina
Redwing	Turdus iliacus
Fieldfare	Turdus pilaris
European Honey Buzzard	Pernis apivorus

Protected birds	
Hawfinch	Coccothraustes coccothraustes
Common Buzzard	Buteo buteo
Mistle Thrush	Turdus viscivorus
Barn Owl	Tyto alba
Goldfinch	Carduelis carduelis
Eurasian Tree Sparrow	Passer montanus
Eurasian Oystercatcher	Haematopus ostralegus
Eurasian Sparrowhawk	Accipiter nisus
Little Owl	Athene noctua
Common Kestrel	Falco tinnunculus
Black Redstart	Phoenicurus ochruros
European Robin	Erithacus rubecula

Amphibia and fish	
Common frog	*Rana temporaria*
Common toad	*Bufo bufo*
Edible Frog	*Pelophylax kl. esculentus*
Common newt	*Lissotriton vulgaris*
Ninespine stickleback	*Pungitius pungitius*

Butterflies	
Mourning Cloak	Nymphalis antiopa
Brown Argus	Aricia agestis
Old World Swallowtail	Papilio machaon
Brown Hairstreak	Thecla betulae

Plants	
Hedgerow Cranesbill	Geranium pyrenaicum
Pale Sedge	*Carex pallescens*
Canadian Pondweed	Elodea canadensis
Broad-leaved Helleborine	Epipactis helleborine
deer fern	*Blechnum spicant*
common cudweed	*Filago vulgaris*
kingcup, marsh marigold	Caltha palustris
grass lily	*Ornithogalum umbellatum*
harebell	*Campanula rotundifolia*
Fuller's teasel	*Dipsacus fullonum*
Spreading Pellitory	*Parietaria judaica*
lesser periwinkle	*Vinca minor*
Horseradish	*Armoracia rusticana*
rampion bellflower	*Campanula rapunculus*
hoary plantain	*Plantago media*
Meadow Thistle	*Cirsium dissectum*

Appendix 2: Species second inventarisation

Overview of species found in research done by Grontmij in 2009 [9]

Bats	
Common pipistrelle	*Pipistrellus pipistrellus*
Nathusius' pipistrelle	*Pipistrellus nathusii*
Serotine bat	*Eptesicus serotinus*
Common noctule	*Nyctalus noctula*
Daubentons bat	*Myotis daubentonii*
Common long-eared bat	*Plecotus auritus*

Other Mammals	
European hedgehog	*Erinaceus europaeus*
European rabbit	*Oryctolagus cuniculus*
European hare	*lepus europaeus*
Roe deer	*Capreolus capreolus*

Birds	
Common buzzard	*Buteo buteo*
Common kestrel	*Falco tinnunculus*
Tawny owl	*Strix aluco*
Little owl	*Athene noctua*
Great spotted woodpecker	*Dendrocopos major*
European green woodpecker	*Picus viridis*

Amphibia and fish	
Smooth newt	*Lissotriton vulgaris*
Common toad	*Bufo bufo*
Common frog	*Rana temporaria*
Edible frog	*Pelophylax kl. Esculentus*
Three-spined stickleback	*Gasterosteus aculeatus*
Nine-spined stickleback	*Pungitius pungitius*
Prussian carp	*Carassius gibelio*
Common carp	*Cyprinus carpio*

Butterflies	
Common blue	*Polyommatus icarus*
Small white	*Pieris rapae*
Green-veined white	*Pieris napi*
Large white	*Pieris brassicae*
Gonepteryx rhamni	*Gonepteryx rhamni*
Holly blue	*Celastrina argiolus*
Meadow brown	*Maniola jurtina*
Speckled wood	*Pararge aegeria*
Painted lady	*Vanessa cardui*
Peacock butterfly	*Inachis io*
Large skipper	*Ochlodes sylvanus*

Essex skipper	*Thymelicus lineola*

Odonata	
Azure damselfly	*Coenagrion puella*
Common blue damselfly	*Enallagma cyathigerum*
Blue-tailed damselfly	*Ischnura elegans*
Small red-eyed damselfly	*Erythromma viridulum*
Common darter	*Sympetrum striolatum*
Ruddy darter	*Sympetrum sanguineum*
Vagrant darter	*Sympetrum vulgatum*
Black-tailed skimmer	*Orthetrum cancellatum*
Emperor	*Anax imperator*
Brilliant emerald	*Somatochlora metallica*
Four-spotted chaser	*Libellula quadrimaculata*

plants	
Epipactis helleborine	*Epipactis helleborine*
Rampion bellflower	*Campanula rapunculus*
Creeping bellflower	*Campanula rapunculoides*

Appendix 3: Bird species of the Bovenste Polder

Overview of special nesting birds for the Netherlands, seen in the Bovenste polder (adaptation of table 2, page 20 [26]).
The number indicates the amount of each species found during one inventarisation in that specific year. Species on the red list are displayed in italics.

Species	**Latin name**	**1975**	**1989**	**1996**	**2004**	**2010**
Marsh Warbler	Acrocephalus palustris	26	24	49	78	56
Eurasian Reed Warbler	Acrocephalus scirpaceus	2	9	16	33	35
Sky Lark	*Alauda arvensis*	*4*	*0*	*0*	*0*	*0*
Common Kingfisher	Alcedo atthis	0	0	0	1	0
Northern Shoveler	*Anas clypeata*	*2*	*0*	*0*	*0*	*2*
Garganey	*Anas querquedula*	*1*	*1*	*0*	*0*	*0*
Gadwall	Anas strepera	0	0	0	0	9
Meadow Pipit	*Anthus pratensis*	*8*	*2*	*4*	*10*	*22*
Little Owl	*Athene noctua*	*2*	*2*	*2*	*2*	*2*
Tufted Duck	Aythya fuligula	0	0	1	0	9
Common Linnet	*Carduelis cannabina*	*9*	*8*	*6*	*5*	*17*
Little Ringed Plover	Charadrius dubius	0	0	0	2	1
Common Quail	*Coturnix coturnix*	*1*	*4*	*0*	*0*	*0*
Corn Crake	*Crex crex*	*2*	*1*	*0*	*0*	*0*
Common Cuckoo	*Cuculus canorus*	*2*	*1*	*2*	*2*	*2*
Crested Lark	*Galerida cristata*	*1*	*0*	*0*	*0*	*0*
Common Snipe	*Gallinago gallinago*	*5*	*5*	*0*	*0*	*1*
Eurasian Oystercatcher	*Haematopus ostralegus*	*0*	*1*	*1*	*0*	*1*
Icterine Warbler	*Hippolais icterina*	*3*	*9*	*2*	*0*	*0*
Black-tailed Godwit	*Limosa limosa*	*3*	*0*	*0*	*0*	*0*
Common Grasshopper Warbler	Locustella naevia	0	0	5	3	6
Bluethroat	Luscinia svecica	0	0	0	4	8
Western Yellow Wagtail	*Motacilla flava*	*4*	*0*	*0*	*2*	*0*
Eurasian Tree Sparrow	*Passer montanus*	*9*	*21*	*17*	*10*	*0*
Gray Partridge	*Perdix perdix*	*8*	*0*	*0*	*0*	*0*
European Green Woodpecker	*Picus viridis*	*0*	*0*	*0*	*0*	*1*
Willow Tit	*Poecile montanus*	*2*	*5*	*6*	*6*	*4*
Spotted Crake	*Porzana porzana*	*1*	*0*	*0*	*0*	*0*
Water Rail	Rallus aquaticus	4	**2**	0	0	1
European Stonechat	Saxicola rubicola	0	0	0	2	8
Common Tern	*Sterna hirundo*	*0*	*0*	*0*	*0*	*2*
European Turtle Dove	Streptopelia turtur	7	**4**	0	0	0
Lesser Whitethroat	Sylvia curruca	***1***	1	1	2	5
Little Grebe	*Tachybaptus ruficollis*	*0*	*1*	*0*	*0*	*0*
Common Shelduck	Tadorna tadorna	2	0	2	1	2
Common Redshank	*Tringa totanus*	*0*	*1*	*1*	*1*	*2*
Northern Lapwing	Vanellus vanellus	24	**5**	1	0	1
Total amount of species		**25**	**20**	**16**	**17**	**23**

Appendix 4: Odonate species of the Bovenste Polder

Overview of Odonate species (Dragonflies and damselflies) in the Bovenste polder (adaptation of table 3¸ page 27 [26]).

* indicates the amount of species found during a time period. Amount index: * = 1-2, ** = 3-9, *** = 10-49, **** = 50-100, ***** = >100, ? = not certain

Species	**latin name**	**1970-1989**	**1990-1996**	**1997-2009**	**2010**
Southern Hawker	*Aeshna cyanea*	*	*	**	
Brown Hawker	*Aeshna grandis*	*	?	*	
Migrant Hawker	*Aeshna mixta*	?	*	**	**
Emperor Dragonfly	*Anax imperator*		?	**	**
Hairy Dragonfly	*Brachytron pratense*			**	*
Banded Demoiselle damselfly	*Calopteryx splendens*			**	*
Azure Damselfly	*Coenagrion puella*	***	*	***	*
Variable Damselfly	*Coenagrion pulchellum*	*	?	**	*
Downy Emerald Dragonfly	*Cordulia aenea*			*	
Scarlet Dragonfly	*Crocothemis eryhtraea*				*
Common Blue Damselfly	*Enallagma cyathigerum*	*	*	**	**
Red-eyed Damselfly	*Eryhtromma najas*	*	*	***	**
Small Red-eyed Damselfly	*Erythromma viridulum*			***	***
Yellow-legged Dragonfly	*Gomphus flavipes*			**	*
Blue-tailed Damselfly	*Ischnura elegans*	*	*	****	***
Scarce Blue-tailed Damselfly	*Ischnura pumilio*				*
Southern Emerald Damselfly	*Lestes barbarus*			*	
Emerald Damselfly	*Lestes sponsa*	?	*		*
Emerald Spreadwing damselfly	*Lestes dryas*	*			
Willow Emerald Damselfly	*Lestes viridis*	*	*	**	*
Large White-faced Darter	*Leucorrhinia pectoralis*	*			
Broad-bodied Darter	*Libellula depressa*	*	*		**
Four-spotted Skimmer	*Libellula quadrimaculata*			*	*
Black-tailed Skimmer	*Orthetrum cancellatum*	*	?	***	***
White-legged Damselfly	*Platycnemis pennipes*	*	*		
Large Red Damselfly	*Pyrrhosoma nymphula*			**	***
Brilliant Emerald dragonfly	*Somatochlora metallica*			*	
The Common Winter Damselfly	*Sympecma fusca*			**	*
Red-veined darter	*Sympetrum fonscolombii*			*	*
Yellow-winged darter	*Sympetrum flaveolum*			*	
Ruddy Darter	*Sympetrum sanguineum*	*	*	**	***
Common Darter	*Sympetrum striolatum*	*	?	**	***
Vagrant Darter	*Sympetrum vulgatum*	*		*	**
total amount of species		**16-18**	**11-16**	**26**	**25**

Appendix 5: Butterfly species of the Bovenste Polder

Butterflies found in the Bovenste Polder
Amount index: * = 1-2, ** = 3-9, *** = 10-49, **** = >50 (adaptation of table 4, page 28 [26]).

Butterfly species	**latin name**	**2010**
Small Tortoiseshell	*Aglais urticae*	***
Orange Tip	*Anthocharis cardamines*	*
Ringlet	*Aphantopus hyperantus*	*
Holly Blue	*Celastrina argiolus*	*
Common Brimstone	*Gonepteryx rhamni*	*
European Peacock	*Inachis io*	**
Wall Brown	*Lasiommata megera*	*
Small Copper	*Lycaena phlaeas*	**
Meadow Brown	*Maniola jurtina*	****
common yellow swallowtail	*Papilio machaon*	*
Speckled Wood	Pararge aegeria	*
Large cabbage white	*Pieris brassicae*	*
Green-veined White	*Pieris napi*	**
Small Cabbage White	*Pieris rapae*	***
Brown Argus	*Plebeius agestis*	**
Comma/anglewing	*Polygonia c-album*	*
Common Blue	*Polyommatus icarus*	****
Essex Skipper	*Thymelicus lineola*	*
Red Admiral	*Vanessa atalanta*	**
Painted Lady	*Vanessa cardui*	*
total amount of species		**20**

Appendix 6: Bird species of the Dreijen

Bird species at the Dreijen. (Adapted from “Bijlage 2” [28])

Breeding bird type	Latin name	gardens	Ponds	Buildings	Connection
Mallard	*Anas platyrhynchos*		X		
Common kestrel	*Falco tinnunculus*			X	
Common Moorhen	*Gallinula chloropus*		X		
Stock dove	*Columba oenas*	X			
Common wood pigeon	*Columba palumbus*	X			X
Eurasian Collared Dove	*Streptopelia decaocto*				X
Common Swift	*Apus apus*			X	
Common Kingfisher	*Alcedo atthis*		X		
European Green Woodpecker	*Picus viridis*	X			
Great Spotted Woodpecker	*Dendrocopos major*	X			X
White Wagtail	*Motacilla alba*			X	
Eurasian Wren	*Troglodytes troglodytes*	X			X
Dunnock	*Prunella modularis*	X			X
European Robin	*Erithacus rubecula*	X			X
Black Redstart	*Phoenicurus ochruros*			X	
Common Blackbird	*Turdus merula*	X			X
Song Thrush	*Turdus philomelos*	X			X
Mistle Thrush	*Turdus viscivorus*	X			
Lesser Whitethroat	*Sylvia curruca*		X		
Eurasian Blackcap	*Sylvia atricapilla*	X			X
Common Chiffchaff	*Phylloscopus collybita*	X			X
Willow Warbler	*Phylloscopus trochilus*	X			
Goldcrest	*Regulus regulus*	X			
Common Firecrest	*Regulus ignicapilla*	X			
Long-tailed Tit	*Aegithalos caudatus*	X			
Marsh Tit	*Poecile palustris*	X			
European Crested Tit	*Lophophanes cristatus*	X			
Blue Tit	*Cyanistes caeruleus*	X			X
Great Tit	*Parus major*	X			X
Eurasian Nuthatch	*Sitta europaea*	X			X
Short-toed Treecreeper	*Certhia brachydactyla*	X			
Eurasian Jay	*Garrulus glandarius*	X			
Eurasian Magpie	*Pica pica*		X		X
Western Jackdaw	*Corvus monedula*				X
Carrion Crow	*Corvus corone*	X			
Common Starling	*Sturnus vulgaris*	X			X
House Sparrow	*Passer domesticus*			X	X
Common Chaffinch	*Fringilla coelebs*	X			X
European Greenfinch	*Carduelis chloris*	X			X
European Goldfinch	*Carduelis carduelis*	X			
Common Linnet	*Carduelis cannabina*				X
Common Bullfinch	*Pyrrhula pyrrhula*	X			

Hawfinch	*Coccothraustes coccothraustes*	X			
total amount of species		**30**	**5**	**5**	**20**

Appendix 7: Butterfly, moth and odonate species of the Dreijen

Butterfly, Moth and Odonate species at the Dreijen. (adapted from “Bijlage 4” [28])

Butterflies		***Odonate (Dragonflies and Damselflies)***	
English name	**Latin name**	**English name**	**Latin name**
Common visitors		**Common visitors**	
European Peacock	*Inachis io**	Large red damselfly	*Pyrrhosoma nymphula*
Small Tortoiseshell	*Aglais urticae**	Blue-tailed Damselfly	*Lschnura elegans*
Comma butterfly	*Polygonia c-album**	Azure Damselfly	*Coenagrion puella*
Small cabbage white	*Pieris rapae**	Small Red Damselfly	*Ceriagrion tenellum*
Cabbage Butterfly	*Pieris brassicae**	Four-spotted Chaser	*Libellula quadrimaculata*
Green-veined White	*Pieris napi**	Emperor Dragonfly	*Anax imperator*
Brown Argus	*Aricia agestis**	Black-tailed skimmer	*Orthetrum cancellatum*
Holly Blue	*Celastrina argiolus**	Red-eyed Damselfly	*Erythromma najas*
Small Copper	*Lycaena phlaeas**	Small Red-eyed Damselfly	*Erythromma viridulum*
Vanessa cardui	*Vanessa cardui*	Vagrant Darter	*Sympetrum vulgatum*
Red Admiral	*Vanessa atalanta*	Common Darter	*Sympetrum striolatum*
Meadow Brown	*Maniola jurtina**	Ruddy Darter	*Sympetrum sanguineum*
Common Blue	*Polyommatus icarus**	Southern Hawker	*Aeshna cyanea*
Occasional visitors		Migrant Hawker	*Aeshna mixta*
Brimstone	*Gonepteryx rhamni*	Willow Emerald Damselfly	*Lestes viridis*
Map	*Araschnia levana**	Brown Hawker	*Aeshna grandis*
Speckled Wood	*Pararge aegeria**	Common Blue Damselfly	*Enallagma cyathigerum*
Essex Skipper	*Thymelicus lineola**	**Occasional visitors**	
Small Skipper	*Thymelicus sylvestris**	Broad-bodied Chaser	*Libellula depressa*
Brown Hairstreak	*Thecla betulae**	Emerald Damselfly	*Lestes sponsa*
Moths		Black Darter	*Sympetrum danae*
Humming bird hawk-moth	*Macroglossum stellatarum*		
Total amount of species	**20**		**20**

Appendix 8: Protected species bus lane area

Protected species which have been spotted or are expected to be present around the future bus line, based on observations in 2009 [12, 146]

Species name	Ff law table
Flora	
Broad-leaved Helleborine (*Epipactis helleborine*)	1
Creeping bellflower (*Campanula rapunculoides*) [A]	1
Rampion bellflower (*Campanula rapunculus*) [A]	2
Mammals	
Hare (*Lepus europaeus*)	1
Rabbit (*Oryctolagus cuniculus*)	1
Roe deer (*Capreolus capreolus*)	1
Greater white-toothed shrew (*Crocidura russula*)	1
Common shrew (*Sorex araneus*)	1
Bank vole (*Myodes glareolus*)	1
European mole (*Talpa europaea*)	1
Field vole (*Microtus agrestis*)	1
Wood mouse (*Apodemus sylvaticus*)	1
Harvest mouse (*Micromys minutus*)	1
Brown rat (*Rattus norvegicus*)	1
European polecat (*Mustela putorius*)	1
Common pipistrelle (*Pipistrellus pipistrellus*)	3 appendix IV
Nathusius' pipistrelle (*Pipistrellus nathusii*)	3 appendix IV
Serotine bat (*Eptesicus serotinus*)	3 appendix IV
Common noctule (*Nyctalus noctula*)	3 appendix IV
Brown long-eared bat (*Plecotus auritus*)	3 appendix IV
Daubenton's bat (*Myotis daubentonii*)	3 appendix I
Amphibia	
Smooth newt (*Lissotriton vulgaris*)	1
Common toad (*Bufo bufo*)	1
Common frog (*Rana temporaria*)	1
Edible frog (*Pelophylax kl. esculentus*)	1
[A] = Most likely introduced by humans, therefore not protected	

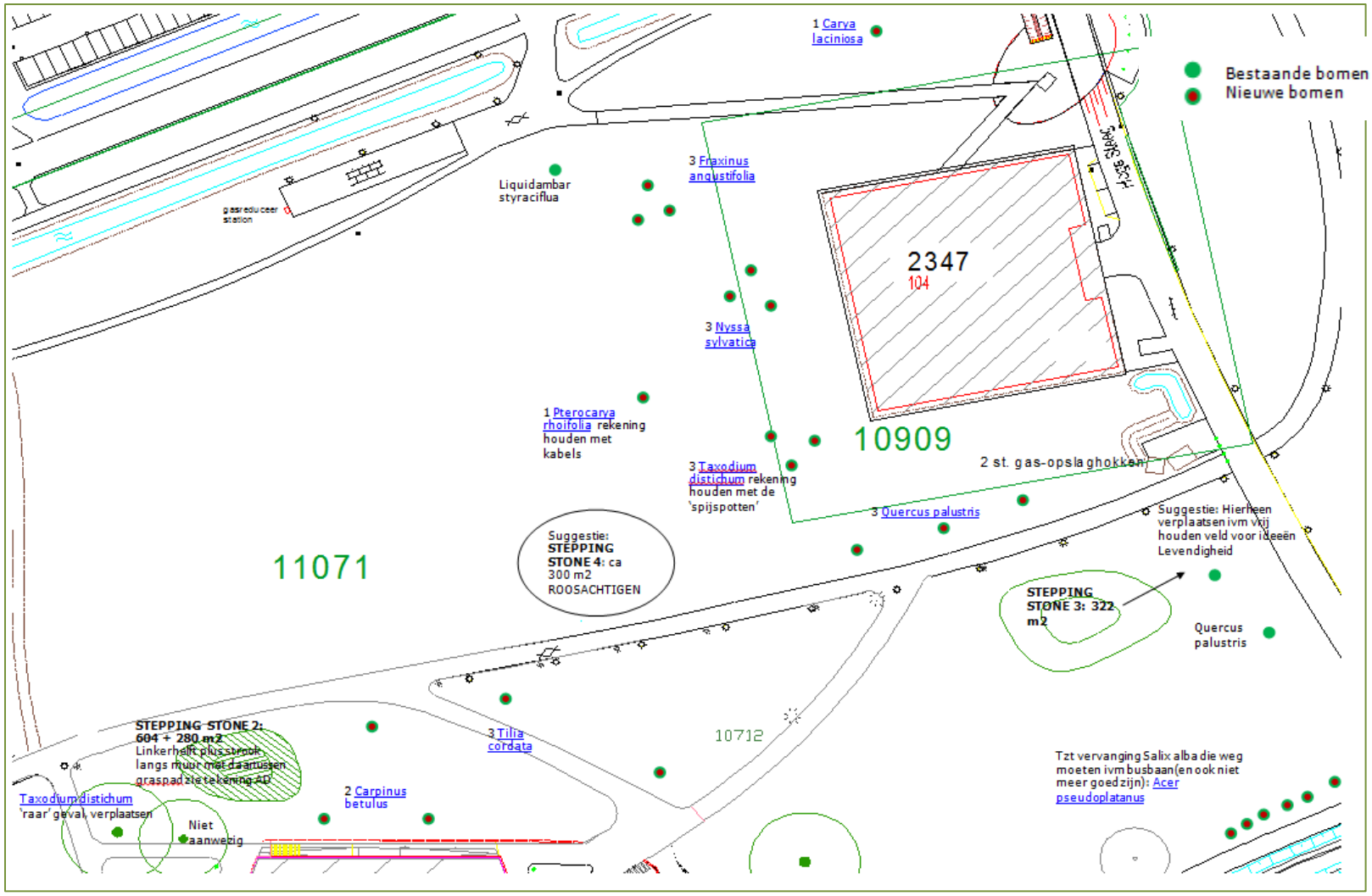
Appendix 9: New trees campus

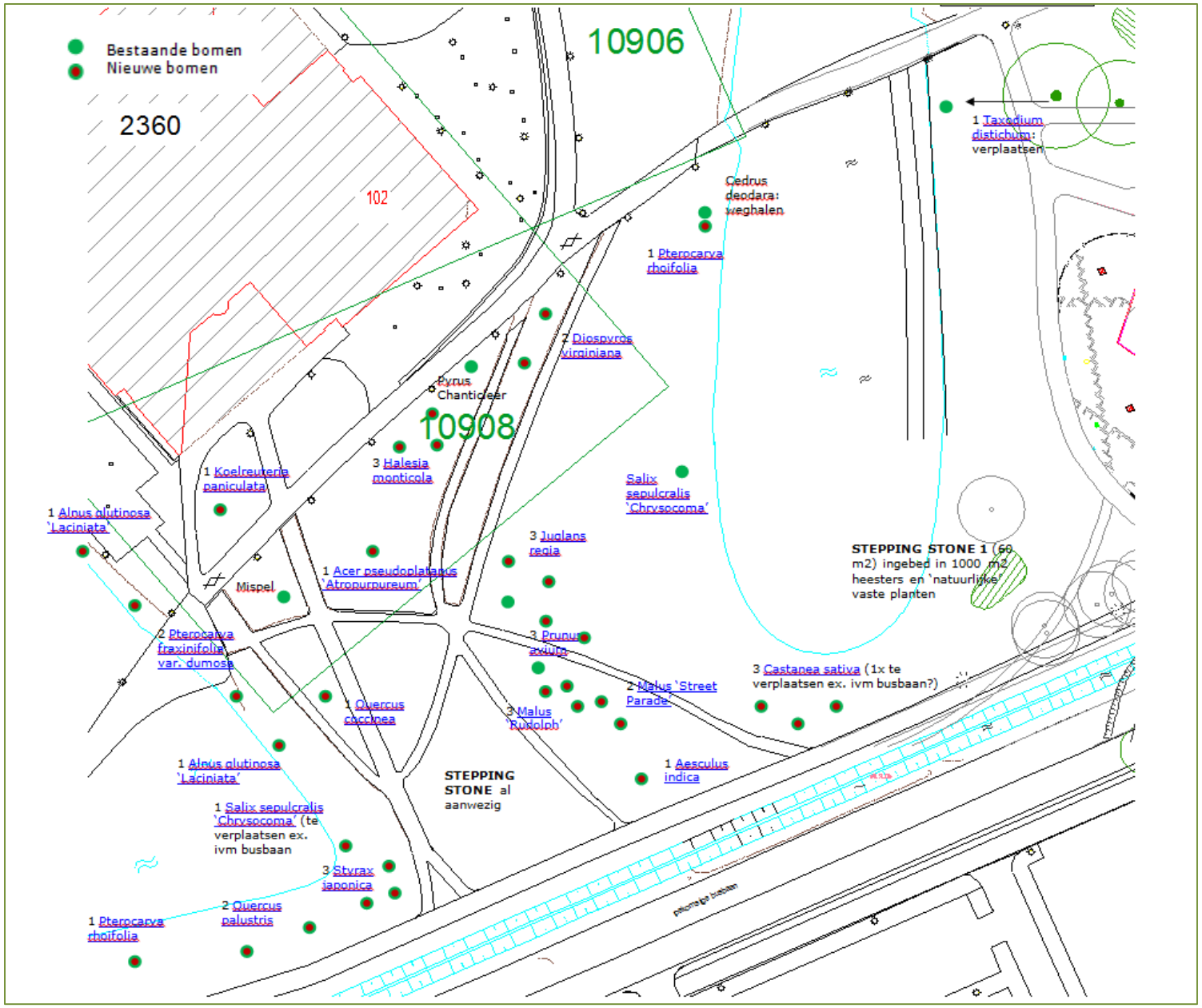
List of new trees (adapted from personal communication Elike Wijnheijmer)

New trees on campus around Forum, Orion and Atlas		
Location	**Species**	**Number**
North side Atlas	Shellbark hickory (*Carya laciniosa*)	1
West side Atlas	Japanese wingnut (*Pterocarya rhoifolia*)	1
	Narrow-leafed ash (*Fraxinus angustifolia*)	3
	Black tupelo (*Nyssa sylvatica*)	3
	Bald cyprus (*Taxodium distichum*)	3
South side Atlas	Pin oak (*Quercus palustris*)	3
Along Bronland	Sycamore maple (*Acer pseudoplatanus*)	unknown
North side Orion	Common hornbeam (*Carpinus betulus*)	2
	Small-leafed lime (*Tilia cordata*)	3
South side of eastern pond	Sweet chestnut (*Castanea sativa*)	3
West side eastern pond	Japanese wingnut (*Pterocarya rhoifolia*)	1
South side Forum	Goldenrain tree (*Koelreuteria paniculata*)	1
	Sycamore maple (*Acer pseudoplatamus*)	1
	Common persimmon (*Diospyros virginiana*)	2
	Mountain silverbell (*Halesia monticola*)	3
	Indian horse chestnut (*Aesculus indica*)	1
	Crab apple (*Malus baccata* "Street parade")	2
	Wild cherry (*Prunus avium*)	2
	English walnut (*Juglans regia*)	2
	Crab apple (*Malus "Rudolph"*)	3
Along shore eastern pond	Japanese wingnut (*Pterocarya rhoifolia*)	1
	Weeping golden willow (*Salix sepulcralis "Chrysocoma"*)	1
	Pin Oak (*Quercus palustris*)	2
	Cut-leaved common alder (*Alnus glutinosa "Laciniata"*)	2
	Caucasian wingnut (*Pterocarya fraxinifolia*)	2
	Japanese snowbell (*Styrax japonica*)	3

Appendix 10: Maps trees and stepping stones

Maps depicting locations of future trees and stepping stones near the Atlas and Forum (personal communication Elike Wijnheijmer)




Bestaande bomen
Nieuwe bomen
2360
102
10906
10908
1 Taxodium distichum: verplaatsen
Cedrus deodara: weghalen
1 Pterocarya rhoifolia
2 Diospyros virginiana
Pyrus Chanticleer
3 Halesia monticola
1 Koelreuteria paniculata
1 Alnus glutinosa 'Laciniata'
Salix sepulcralis 'Chrysocoma'
3 Juglans regia
1 Acer pseudoplatanus 'Atropurpureum'
Mispel
STEPPING STONE 1 (60 m2) ingebed in 1000 m2 heesters en 'natuurlijke' vaste planten
2 Pterocarya fraxinifolia var. dumosa
3 Prunus avium
3 Castanea sativa (1x te verplaatsen ex. ivm busbaan?)
2 Malus 'Street Parade'
1 Quercus coccinea
3 Malus 'Rudolph'
1 Alnus glutinosa 'Laciniata'
STEPPING STONE al aanwezig
1 Aesculus indica
1 Salix sepulcralis 'Chrysocoma' (te verplaatsen ex. ivm busbaan
3 Styrax japonica
2 Quercus palustris
1 Pterocarya rhoifolia

Appendix 11: New plants around Orion

Species	Size	Number
Dryopteris filix-mas	20-40	175
Cornus sanguinea	60-80	50
Fargesia rufa	80-100	24
Fargesia robusta	110-140	15
Carya laciniosa	20-25	1
Stephanandra incisa		100
Spirea japonica		150
Koelreuteria paniculata	Multiple stems	1
Liriodendron tulipifera	Ho 20-25	1
Aronia melanocarpa	40-60	120
Diervilla sessilifolia	40-60	150
Ilex aquifolium	60-80	45
Hydrangea paniculata	40-60	30
Stephanandra tanakea	40-60	150
Cornus mas	80-100	3
Amelanchier lamarckii	Multiple stems	3
Liriodendron tulipifera	Ho 20-25	1
Tilia tomentosa	Ho 20-25	
Teucrium chamaedrys	P9	720
Nepeta racemosa	P9	400
Phlomis russeliana	P9	640
Buddleja davidii	40-60	20
Cornus controversa	Ho 20-25	1
Itea virginica	30-50	100
Myrica gale	30-50	330
Salix purpurea	40-60	130
Fothergilla major	40-60	75
Viburnum opulus	20-40	330
Ilex aquifolium	60-80	3
Viburnum opulus	60-80	14
Euonymus europeaus	60-80	14
Lathyrus vernus	P9	140
Carex morrowii	P9	140
Scabiosa lachnophylla	P9	50
Astrantia major	P9	110
Origanum vulgare	P9	160
Stachys officinalis	P9	120
Geranium pyrenaicum	P9	110
Symphytum grandiflorum	P9	130
Chrysogonum virginianum	P9	70
Alchemilla mollis	P9	95

Species	Size	Number
Amsonia orientalis	P9	95
Calamintha nepeta	P9	95
Brunnera macrophylla	P9	140
Aster divaricatus	P9	140
Geranium nodosum	P9	105
Teucrium hyrcanicum	P9	140
Succisella inflexa	P9	140
Iris foetidissima	P9	154
Vernonia crinata	P9	90
Helianthus	P9	90
Persicaria amplexicaulis	P9	100
Phlox paniculata	P9	100
Artemisia lactiflora	P9	100
Eupatorium maculatum	P9	85
Ligularia stenocephala	P9	85
Rabdosia longituba	P9	55
Aruncus 'Horatio hybrid'	P9	55
Thalictrum actaefolium	P9	110
Gillenia trifoliata	P9	110
Aster macrophyllus	P9	70
Cicerbita plumieri	P9	40
Persicaria bistorta	P9	150
Ligularia dentata	P9	150
Hemerocallus citrina	P9	120
Laserpitum siler	P9	120
Persicaria amplexicaulis	P9	90
Iris sibirica	P9	100
Sanguisorba menziesii	P9	120
Lythrum virgatum	P9	100
Sanguisorba officinalis	P9	100
Callirhoe bushii	P9	100
Geranium psilostemom	P9	150
Aster glehnii	P9	70
Galega officinalis	P9	80

Appendix 12: New stepping stone composition

Stepping stone 2			
Number	Species	Height (cm)	Description
60	Cornelian cherry (*Cornus mas*)	500	Bees, red berry for birds
60	June berry (*Amelanchier lamarckii*)	500	red-brown berry for birds
60	Common privet (*Ligustrum vulgare*)	500	butterflies, black berry
35	Common hazel (*Corylus avellana*)	600	bees, hazelnuts
35	Bird cherry (*Prunus padus*)	600	black/red stone fruit

Stepping stone 3			
Number	Species	Height (cm)	Description
20	Common holly (*Ilex aquifolium*)	500	red berry
60	Guelder rose (*Viburnum opulus*)	500	red berry
60	Common spindle (*Euonymus europeaus*)	500	pink/orange fruit
40	Common hawthorn (*Cratagus monogyna*)	500	bees, flies. Red berry for birds

Stepping stone 4			
Number	Species	Height (cm)	
20	Cherry plum (*Prunus cerasifera*)	600	bees, cherries
60	Dog rose (*Rosa canina*)	350	bees, orange fruits
60	Purple chokeberry (*Aronia x prunifolia*)	250	bees, black berry for birds (and humans)
20	Common hawthorn (*Cratagus monogyna*)	500	bees, flies, red berry for birds
80	Redcurrant (*Ribes rubrum)*	200	bees, red berry for birds (and humans)
80	Black currant (*Ribes nigrum*)	200	bees, black berry
80	Red raspberry (*Rubus idaeus*)	200	bees, raspberry

Appendix 13: Plants in stone hedges

Adapted from [63]			
Suitable plants =		Not suitable plants/unknown =	
Family and species name	Common names	Additional info	Suitable?
Adiantaceae			
Adiantum capillus-veneris	Maidenhair-fern	Only found in Limburg	?
Aspleniaceae			
Asplenium trichomanes	Maidenhair Spleenwort		yes
Boraginaceae			
Echium vulgare	Vipers' Bugloss		yes
Compositae			
Anthemis tinctoria	Yellow Chamomile	Damages rocks more	?
Crassulaceae			
Sedum album L.	White Stonecrop		yes
Sedum dasyphyllum	Thick-leaved Stonecrop		yes
Umbilicus rupestris	Pennywort		yes
Cruciferae			
Cheiranthus cheiri	Wallflower	Rare and endangered	no
Gramineae			
Cynodon dactylon	Bermuda-grass		yes
Guttiferae			
Hypericum perforatum	Common St John's Wort		Yes
Hypolepidaceae			
Pteridium aquilinum	Bracken		yes
Labiatae			
Calamintha nepeta	Lesser Calamint		yes
Liliaceae			
Allium ampeloprasum	Wild Leek		yes
Papaveraceae			
Chelidonium majus	Greater Celandine		yes
Scrophulariaceae			
Antirrhinum majus	Snapdragon	Not winter hardy	no
Cymbalaria muralis	Ivy-leaved Toadflax	Winter hardy	yes
Urticaceae			
Parietaria diffusa	Pellitory of the Wall	Highly allergenic	no
Valerianaceae			
Centranthus ruber	Red Valerian		Yes

Appendix 14: Insect-attracting plants

Plants for butterflies [134]:

Host plant	Butterfly species
small nettle (*Urtica urens*)	Small Tortoiseshell (*Aglais urticae*), European Peacock (*Inachis io*), Map (*Araschnia levana*)
common nettle (*Urtica*)	Small Tortoiseshell (*Aglais urticae*), European Peacock (*Inachis io*), Map (*Araschnia levana*), Comma/angle wing (*Polygonia c-album*), Red Admiral (*Vanessa atalanta*), Painted Lady (*Vanessa cardui*), Map (*Araschnia levana*)
Cockoo flower (*Cardamine pratensis*)	Orange Tip (*Anthocharis cardamines*)
Cock's-foot (*Dactylis glomerata)*	Ringlet (*Aphantopus hyperantus*), Wall Brown (*Lasiommata megera*), Meadow Brown (*Maniola jurtina*), Speckled Wood (*Pararge aegeria*), Essex Skipper (*Thymelicus lineola*), Small Skipper (*Thymelicus sylvestris*)
Bents (*Agrostis* spp.)	Wall Brown (*Lasiommata megera*), Meadow Brown (*Maniola jurtina*), Essex Skipper (*Thymelicus lineola*)
Buckthorn (*Rhamnus cathartica*)	Common Brimstone (*Gonepteryx rhamni*), Brimstone *(Gonepteryx rhamni)*
Hop (*Humulus lupulus*)	European Peacock (*Inachis io*), Comma/angle wing (*Polygonia c-album*), Red Admiral (*Vanessa atalanta*)
False Brome (Brachypodium sylvaticum)	Ringlet (*Aphantopus hyperantus*), Wall Brown (*Lasiommata megera*), Meadow Brown (*Maniola jurtina*), Essex Skipper (*Thymelicus lineola*), Small Skipper (*Thymelicus sylvestris*)
Garlic mustard (*Alliaria petiolata)*	Orange Tip (*Anthocharis cardamines*), Small cabbage white (*Pieris rapae*)
Common Couch (*Elytrigia repens*)	Ringlet (*Aphantopus hyperantus*), Speckled Wood (*Pararge aegeria*), Essex Skipper (*Thymelicus lineola*)
Elms (*Ulmus* spp.)	Comma/angle wing (*Polygonia c-album*)
Meadow Foxtail (*Alopecurus pratensis*)	Small Skipper (*Thymelicus sylvestris*), Essex Skipper (*Thymelicus lineola*)
Tor-grass (*Brachypodium pinnatum*)	Meadow Brown (*Maniola jurtina*), Essex Skipper (*Thymelicus lineola*)
Wavy Hair-grass (*Deschampsia flexuosa*)	Meadow Brown (*Maniola jurtina*)
Yorkshire-fog (*Holcus lanatus*)	Wall Brown (*Lasiommata megera*), Meadow Brown (*Maniola jurtina*), Speckled Wood (*Pararge aegeria*), Small Skipper (*Thymelicus sylvestris*)
Meadow-grasses (Poa spp.),	Ringlet (*Aphantopus hyperantus*)
Nasturtium (*Tropaeolum majus*)	Large cabbage white (*Pieris brassicae*), Small cabbage white (*Pieris rapae*)
Brassicaceae	Large cabbage white (*Pieris brassicae*), Small cabbage white (*Pieris rapae*)
Milk-parsley (*Peucedanum palustre*)	common yellow swallowtail (*Papilio machaon*)
Dill (Anethum graveolens)	common yellow swallowtail (*Papilio machaon*)
White Clover (*Trifolium repens*)	Common Blue (*Polyommatus icarus*)
Blackthorn (*Prunus spinosa*)	Brown Hairstreak (*Thecla betulae*)
Bullace (*Prunus domestica*)	Brown Hairstreak (*Thecla betulae*)
Common Sorrel (*Rumex acetosa*)	Small Copper (*Lycaena phlaeas*)
Sheep's Sorrel (*Rumex acetosella*)	Small Copper (*Lycaena phlaeas*)
Broad-leaved Dock (*Rumex obtusifolius*)	Small Copper (*Lycaena phlaeas*)

Plants for honeybees [100]

English name	Latin name
White clover	*Trifolium repens*
Red clover	*Trifolium pratense*
Hemp agrimony	*Eupatorium cannabinum*
Small scabious	*Scabiosa columbaria*
Marjoram	*Origanum vulgare*
Field scabious	*Knautia arvensis*

Corn flower	*Centaurea cyanus*
Wild teasel	*Dipsacus fullonum*
Common mallow	*Malva sylvestris*
Musk mallow	*Malva moschata*
Common vetch	*Vicia sativa*
Purple loosestrife	*Lythrum salicaria*
Wild clary	*Salvia verbenacea*
Meadow clary	*Salvia pratensis*
Common bird's foot trefoil	*Lotus corniculatus*
Foxglove	*Digitalis purpurea*
Hedge woundwort	*Stachys sylvatica*
Ragged robin	Silene *flos-cuculii*
Marsh woundwort	*Stachys palustris*
White deadnettle	*Lamium album*
Red campion	*Silene dioica*
Toadflax	*Linaria vulgaris*
White campion	*Silene latifolia*
Soapwort	*Saponaria officinalis*

Plants for lacewing attraction [147, 148]

English name	**Latin name**
Alfalfa	*Medicago sativa*
Golden marguerite	*Anthemis tinctoria*
Four-wing saltbush	*Atriplex canescens*
Purple poppy mallow	*Callirhoe involucrata*
Coriander	*Coriandrum sativum*
Caraway	*Carum carvi*
Cosmos white sessation	*Cosmos bipinnatus*
Queen anne’s lace	*Daucus carota*
Prairie sunflower	*Helianthus maximilianii*
Tansy	*Tanacetum vulgare*

Plants for ladybug attraction *[148]*

English name	**Latin name**
Fern-leaf yellow	*Achillea filipendulina*
Common yarrow	*Achillea millefolium*
Golden marguerite	*Anthemis tinctoria*
Dill	*Anethum graveolens*
Dwarf alpine aster	*Aster alpinus*
Masterwort	*Astrantia major*
Purple poppy mallow	*Callirhoe involucrata*
Coriander	*Coriandrum sativum*
Caraway	*Carum carvi*
Cosmos white sensation	*Cosmos bipinnatus*
Queen anne's lace	*Daucus carota*
Lemon balm	*Melissa officinalis*

Plants for parasitic wasp attraction [148]

English name	**Latin name**
Common yarrow	*Achillea millefolium*
Lavender globe lily	*Allium tanguticum*
Caraway	*Carum carvi*
Golden marguerite	*Anthemis tinctoria*
Masterwort	*Astrantia major*
Purple poppy mallow	*Callirhoe involucrata*
Coriander	*Coriandrum sativum*
Cosmos white sensation	*Cosmos bipinnatus*
Queen anne's lace	*Daucus carota*
Fennel	*Foeniculum latifolium*
Crimson thyme	*Thymus serpyllum coccineus*
Statice	*Limonium latifolium*
Butter and eggs	*Linaria vulgaris*
Tansy	*Tanacetum vulgare*
Lemon balm	*Melissa officinalis*
Dill	*Anethum graveolens*
Sweet alyssum-white	*Lobularia maritima*
Parsley	*Petroselinum crispus*
Marigold-lemon gem	*Tagetes tenuifolia*

Plants for beneficial fly attraction [148]

English name	**Latin name**
Golden marguerite	*Anthemis tinctoria*
Buckwheat	*Fagopyrum esculentum*
Lemon balm	*Melissa officinalis*
European **pennyroyal**	*Mentha pulegium*
Parsley	*Petroselinum crispum*
Phacelia	**Phacelia** tanacetifolia
Tansy	*Tanacetum vulgare*
Crimson thyme	*Thymus serpyllum coccineus*

Plants for bug attraction [148]

English name	**Latin name**
Caraway	*Carum carvi*
Cosmos white sensation	*Cosmos bipinnatus*
Fennel	*Foeniculum latifolium*
Alfalfa	*Medicago sativa*
Spearmint	*Mentha spicata*
European goldenrod	*Solidago virgaurea*
Marigold-lemon gem	*Tagetes tenuifolia*