1.3 Temperature, geography and and history

1.3.1 Spatial variation

The Earth

Latitudinal differences account for the largest global variations (from approx. -40℃ to 30℃) in average monthly temperatures (*Fig. 63* and *Fig. 64*).

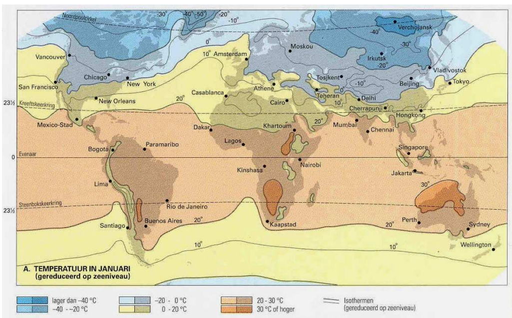


Fig. 63 Global winter temperatures

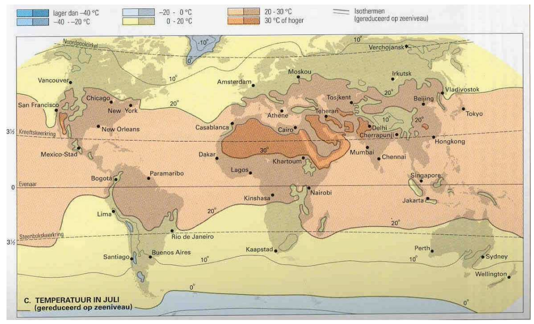


Fig. 64 Global summer temperatures[a]

Europe

Latitudinal differences account for most of the average monthly temperature variations in Europe, but these are moderated by the sea from approx. -15℃ to 25℃ (*Fig. 65* and *Fig. 66*).

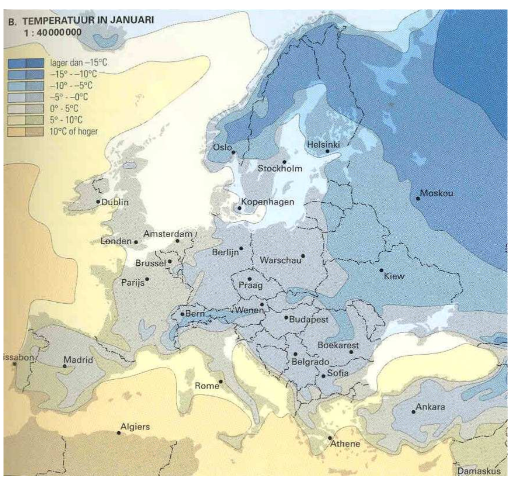


Fig. 65 Winter temperatures in Europe

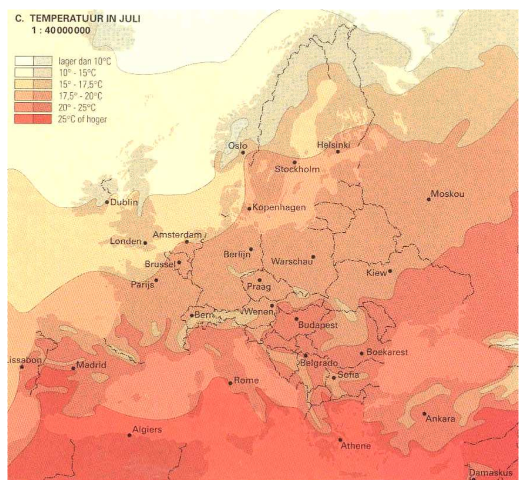


Fig. 66 Summer temperatures in Europe[b]

[a] Wolters-Noordhof (2001) page 180
[b] Wolters-Noordhof (2001) page 71

The Netherlands

Latitudinal differences account for most of the average monthly temperature variation in the Netherlands, but they are moderated by the sea, especially in winter, from approx. 3℃ to 17℃ (*Fig. 67* and *Fig. 68*).

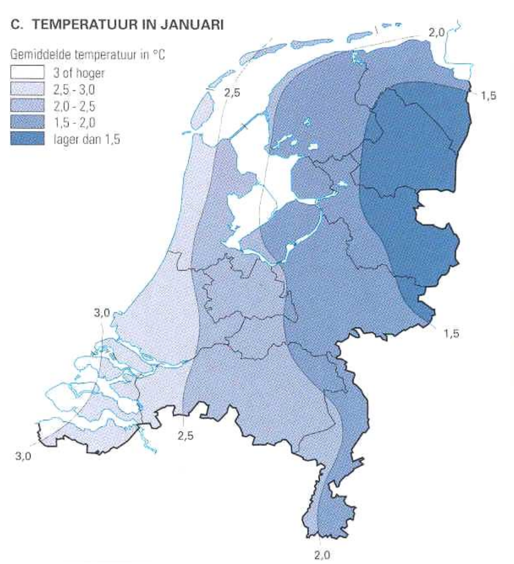


Fig. 67 Winter temperatures in the Netherlands

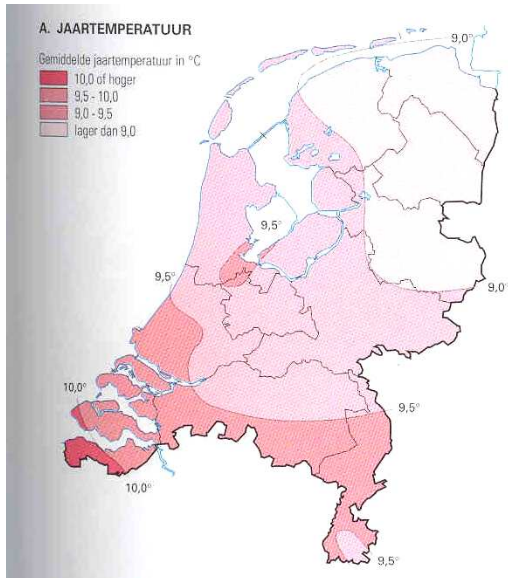


Fig. 68 Year temperatures in the Netherlands[a]

Heat islands

The study of urban heat islands (see *Fig. 69*) has become synonymous with the study of urban climate. Since the increased urbanization and industrialization of the middle of the twentieth century the intensity and the extent of the thermal anomalies has grown. The urban heat island influences physiological comfort, cooling and heating requirements, air circulation and precipitation.

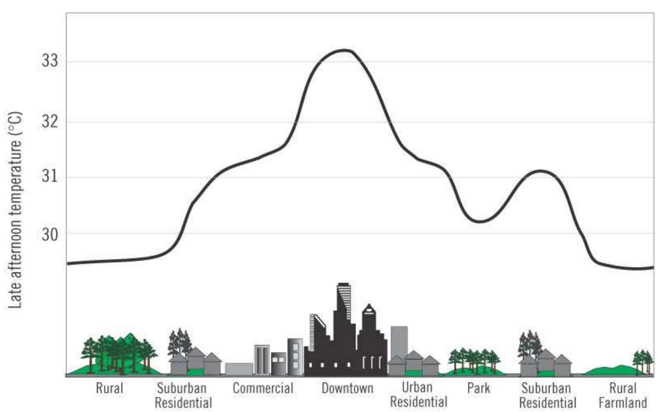


Fig. 69 The urban heat island[b]

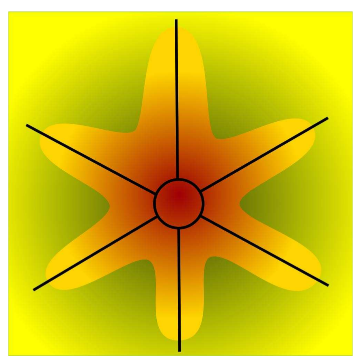


Fig. 70 “Green finger parks” as a contra form of radials in the city

The structure of the city itself influences also the climatic conditions of the city through the density of the buildings, the urban open space, the width of the streets, the crookedness of the streets, the

[a] Wolters-Noordhof (2001) page 43
[b] *http://adaptation.nrcan.gc.ca/perspective/health_3_e.php*

squares and the occurrence of parks and trees aligning streets or squares. Wind velocity will not be discussed in this section.

What causes the urban heat island?

What causes the differences in climatic conditions between an urban area and the surrounding rural areas? The urban heat island is caused by the large heat capacity and the high heat conductivity of urban building material. These facts prevent also a rapid cooling of the urban environment after sunset. This balance causes all kind of movements from the surroundings of a city to the city. The heat island is also equally influenced by other factors such as: rapid runoff of precipitation and as a result a lower amount of evapotranspiration. Through all the buildings and metalled surface the city does not have left over a lot of space where rain can infiltrate the soil. The rain will stream in the sewers and will be discharged immediately. The extra heat in the form of waste heat from urban and industrial buildings the year round together with the heat from the air conditioning in the summer deliver an equally important amount of heat to the city.

Contrast with rural areas

This is in great contrast with the situation in rural areas, where the heat capacity is substantially lower. The heat conductivity is also lower in the rural area. The extra heat delivery by buildings and industry is also nearly negligible.

The differences between urban and rural areas concerning heat capacity and conductivity and the other above mentioned factors make it possible to draft an energy balance between these two areas. This balance alters dependent on the situation such as summer-winter, sunshine or rainfall.

The differences are responsible for pressure differences in the atmosphere and cause equalization by a streaming of air from an area with high air pressure towards an area with a low air pressure. This means a streaming of air from the colder rural area towards the warmer city or a wind blowing towards the city. The wind is relatively cooler then the temperature in the city. The wind will have the Buys Ballot deviation so it will have a deviation to the right on the northern hemisphere and to the left on the southern hemisphere.

Differences in the built up area

Of course there are heat differences in the built up area. It will be obvious that the heat capacity and the heat conductivity will be different for the various urban fabrics. They will be influenced strongly by the cover and the shape of roofs i.e. tiles or bitumen and flat or with inclination, metalled surfaces and parks in combination with water bodies like lakes and canals. Especially the parks with water bodies can have a positive influence on temperature. The temperature there is lower than in the surrounding urban area. If a wind blowing in the city from the rural area outside the built up area passes a large enough park the temperature of the air will cool down. The form of the parks in the built up area plays an important role. Since the air does not flow directly in a straight stream from outside to the centre of a city but with a curve, a belt of parks around the city will not be so effective as “green finger parks” in the form of radials in the city (see *Fig. 70*).

Local variation

In the Netherlands, on 3rd March 1976, the differences in local temperatures, within metres of each other, ranged from -2℃ to 62℃ (Fig.34)!
The air temperature at a height of 1 metre (*Fig. 71*) was 11.8℃.

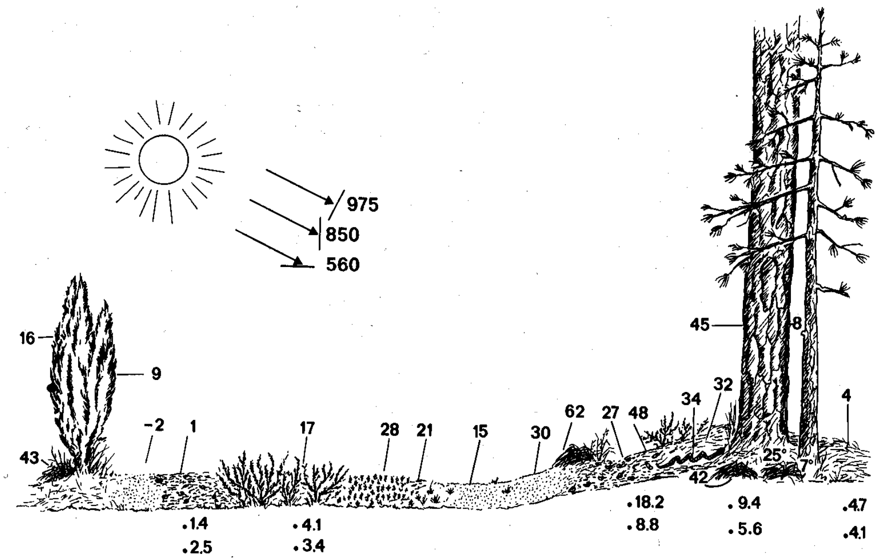


Fig. 71 Surface temperatures along a line perpendicular to edge of a forest[a]

[a] Barkman and Stoutjesdijk (1987) citing Stoutjesdijk (1977)

Individual variation

Plants are long term indicators of local climate and environment (sun, wind, water, soil) while occasional measurements give a random indication of moments.
Plants receiving shadow throughout the day in the growing seasons grow larger and narrower (etoilement) than the same species receiving more sunlight. They look for light rising as high they can (see *Fig. 72*A).

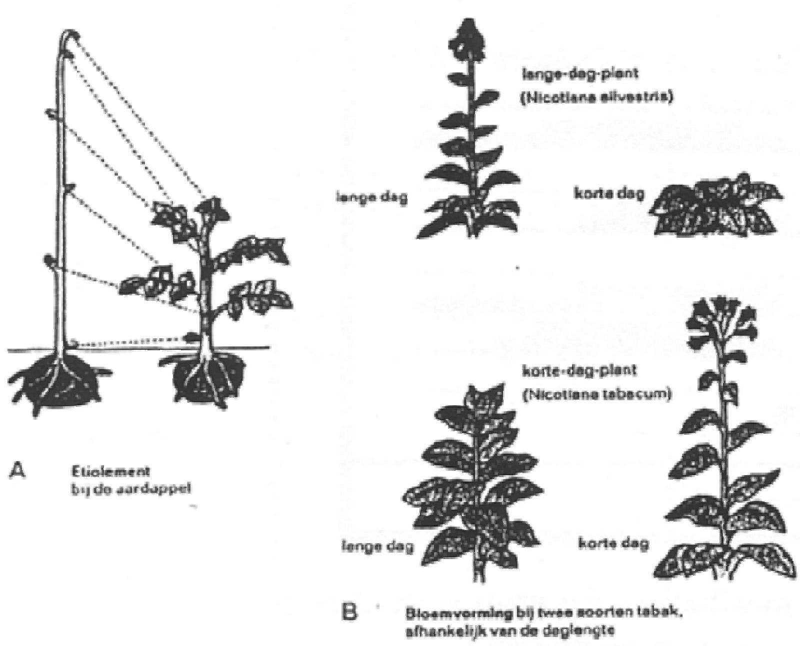


Fig. 72 The influence of variations in light[a]

A plant can not grow if the day is too short (see *Fig. 72*B above).
However, some species are adapted in a way they grow better if the day is short (see *Fig. 72*B below).

The plant species listed below occur so widely that it is well worth while getting to know them.
In the tables below, a number of plants are mentioned in the month in which they can first be encountered in the Netherlands.

[a] Vogel, Günter et al. (1970) page 198, 199

1.3.2 Long term temporal variation

The distance to the sun 'vibrates' in periods of 100 000 years or less, causing ice ages and great differences in wind, water, earth and life stored and named in layers of soil (*Fig. 73*).

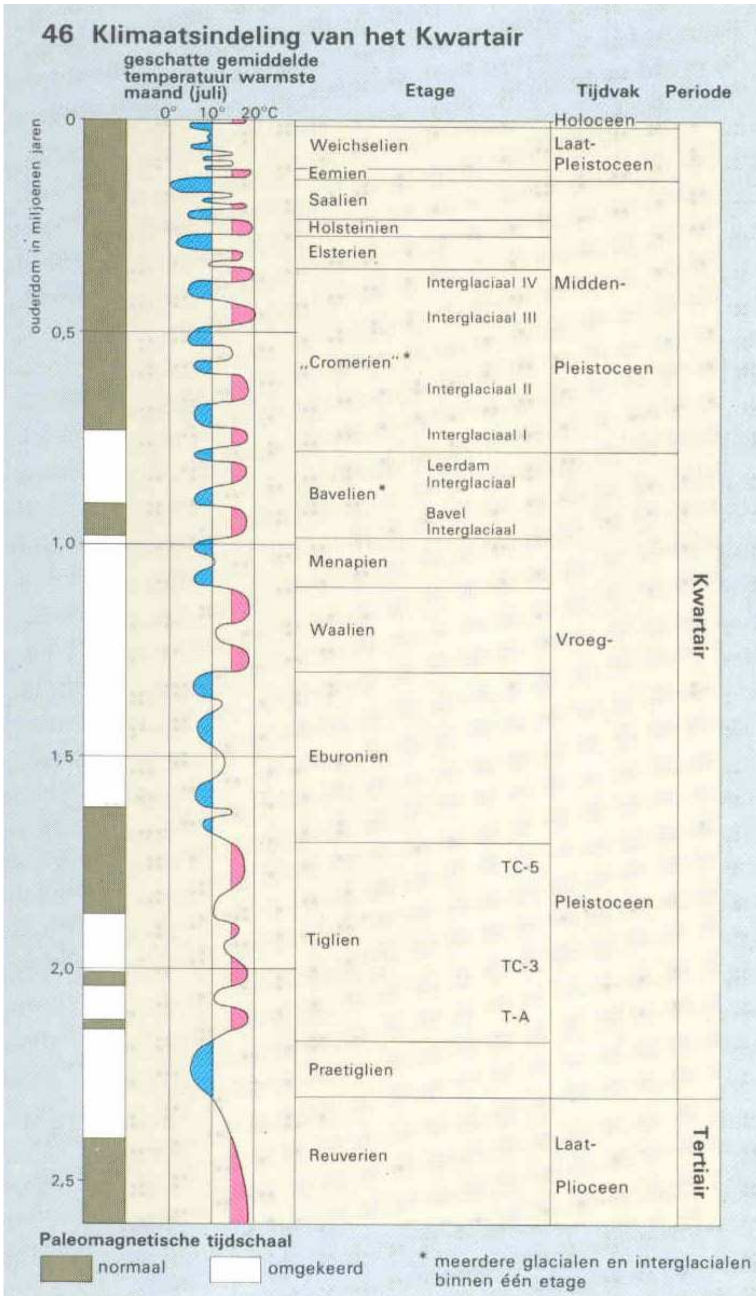


Fig. 73 Temperature fluctuations in The Netherlands in the past 3 million years[a]

These impacts are readable from the topographic history of The Netherlands (Fig. 74).[30]

[a] Sticht.Wetensch.Atlas_v.Nederland (1985)page 13

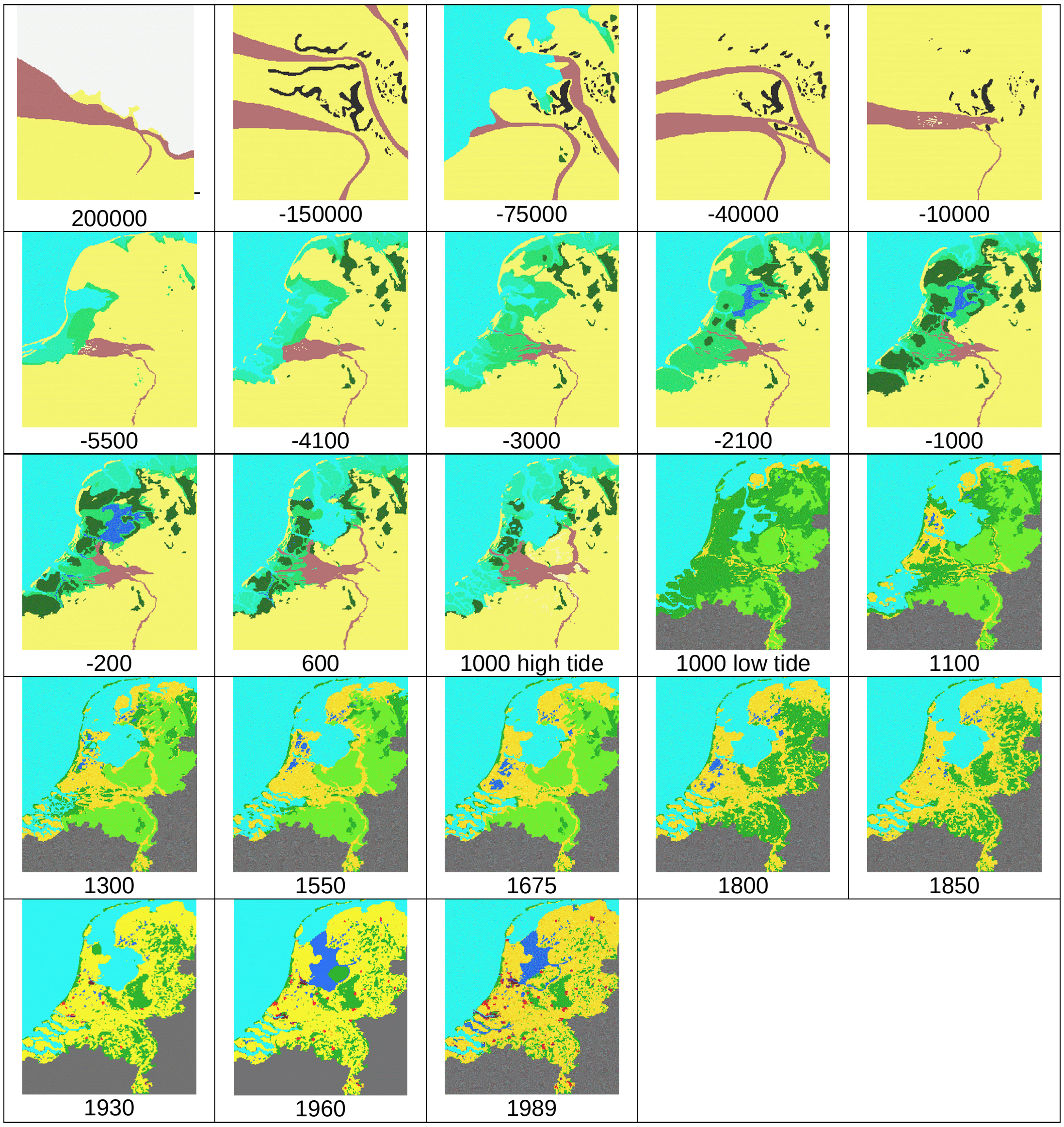


Fig. 74 *De topographic history of The Netherlands*[a]

[a] Universiteit van Utrecht 1987 commisioned by Nederland Nu Als Ontwerp

The Dryas and Alleröd Periods (from 10,000 years BC)

In the famous Lascaux caves, people have made images of mammoths and long haired rhinos. These animals became extinct during the last Ice Age. In Scandinavian countries this period is known as Weichsel and in the Alpine countries as Würm. A tundra plant '*dryas octopetala'* grew in our part of Europe at that time and gave its name to the last cold period of the Weichsel.

15 000 – 10 000 b.C. Older Dryas period

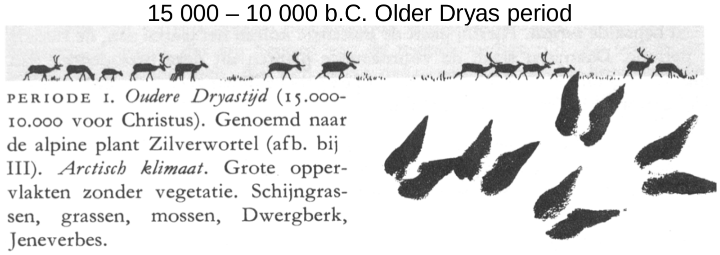
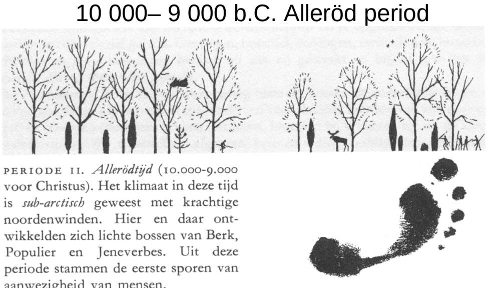


Fig. 75 The end of the Weichsel ice age, the Dryas period[a]

Fig. 76 Vegetation during the Dryas period[b]

Comment [T.M. de2]: Pagina : 57

10 000– 9 000 b.C. Alleröd period



9 000 – 8 000 b.C.

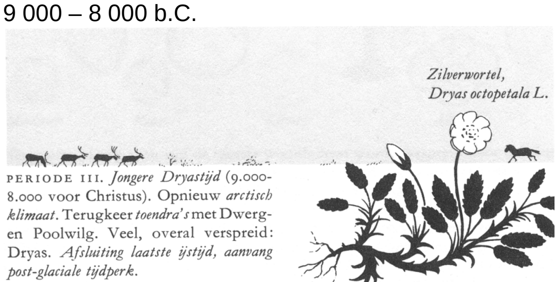


Fig. 77 Sub-divisions of the Dryas [c]

Comment [T.M. de4]: Pagina : 57

Comment [T.M. de3]: Pagina : 57

[a] University of Utrecht 1987
[b] Vedel and Lange (1974)
[c] *Vedel and Lange (1974) p 216*

The PreBoreal and Boreal Periods (from 8,000 BC)

In the warmer periods that followed the Dryas, people learnt how to hunt smaller animals using correspondingly smaller stone tools. The Mesolithicum, the Middle Stone Age, had already started, and peat was also beginning to form due to the warmer climate.

About 8,000 BC the oceans began to rise again, because of the melting ice, and the North Sea filled with water again.In the Netherlands, peat formation began late in the Boreal Period, after the cold extensions of the Dryas and Pre-Boreal, and this continued into the warm and humid Atlanticum. The rising sea levels flooded western parts of the country.

Pre-Boreal (8,000 BC) Early Boreal (7,000 BC)

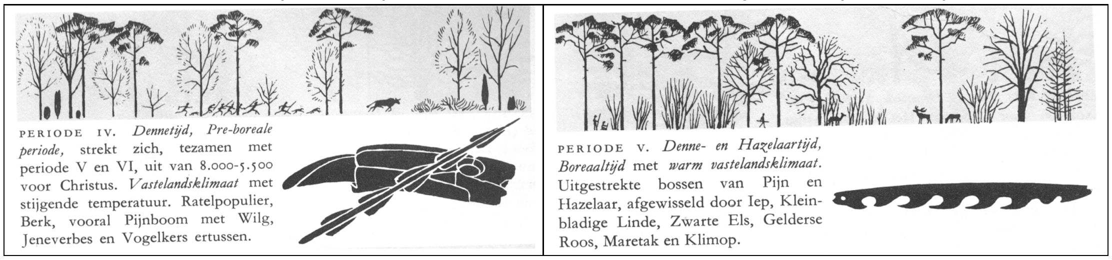


Fig. 78 The landscape of the Pre-Boreal and Early Boreal [a]

Approximately 5,500 BC the sea formed off-shore bars that during the ebb tide were blown higher, forming dunes. In the Waddenzee, behind the dunes, fine sand and silt were deposited, successively, on top of the peat base. The silt became the ‘old’ or ‘blue’ marine clay of (the provinces of) Holland.

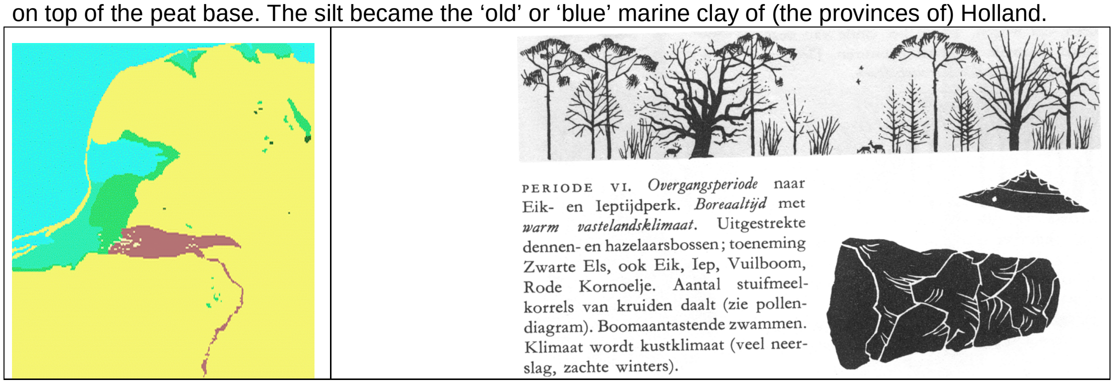


Fig. 79 The Boreal landscape. (from 5,500 BC) [b]

[a] Vedel and Lange (1974)
[b] University of Utrecht(1987), Vedel and Lange (1974)

Atlanticum (from approx. 4,000 BC)

While ever the sea continues to rise, the coast and the peat advance. Approx. 3,000 BC the rise in sea level began to slow down; the off-shore bars remained intact and these broadened out seawards to form a strong coast.

A new row of dunes was laid down in front of the old ones and the peat that had grown on top of the blue marine clay, in so far as the sea had not washed it away, was dug out later. Peat streams first became estuaries and then reverted back to peat streams again. The sea cut into the Sub-Boreal peat leaving channels in which fine sand was deposited. Subsequent drainage caused a reversal in relief.

Atlanticum (4,100 BC). Atlanticum (3,000 BC)

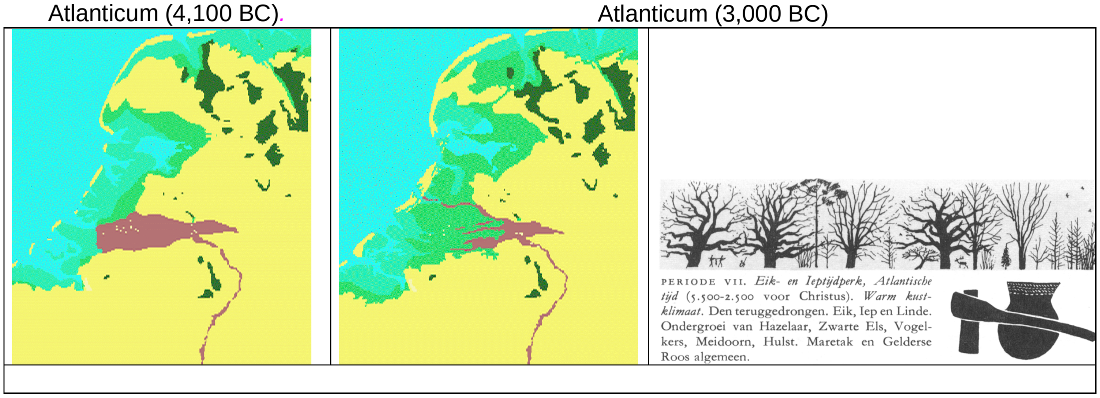


Fig. 80 The landscape of the Atlanticum[a]

The Sub-Boreal (from approx. 2,000 BC)

Approx. 2,100 BC, rivers carred fresh water into the lagoon behind the off-shore bars, causing widespread peat formation

Fig. 81 The Sub-Boreal landscape[b]

Late Boreal and Sub-Atlanticum, from 1000 BC.

Approx. 1,000 BC: The stagnation of water from streams also causes *hoogveen* (i.e. peat formations above the water table) to develop on the lower parts of sandy ground (e.g., the Peel and Drente).

Approx. 200 BC: peat erosion also occurs along the shores of the Almere lake (Zuiderzee area), thereby extending the lake.

[a] University of Utrecht(1987), Vedel and Lange (1974)
[b] University of Utrecht(1987), Vedel and Lange (1974)

Late Sub-Boreal, 1000 BC Sub-Atlanticum, 200 BC

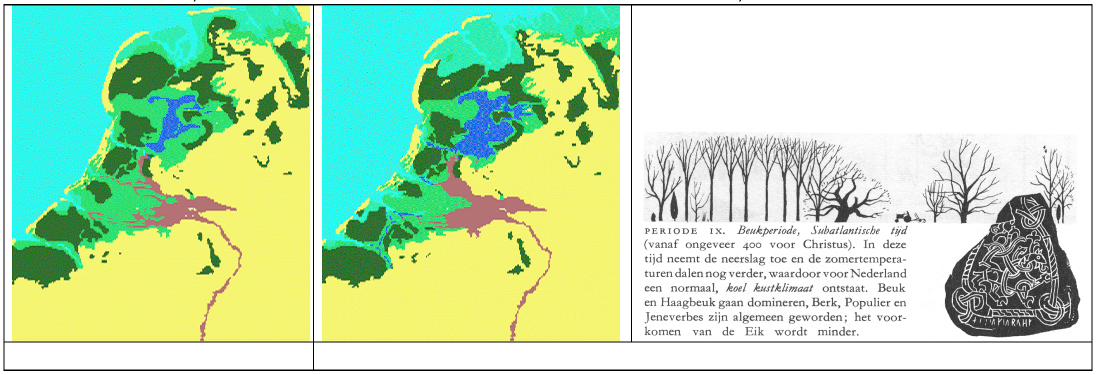


Fig. 82 The Sub-Boreal landscape and Subatlanticum[a]

The Roman period and early Middle Ages, from 100 BC.

Approx. 100 BC: The sea attacked again and large areas of the *laagveen* (i.e. peat formations below the water table) were washed away: this continued for centuries. Bloemers, Kooijmans et al. (1981) and Klok and Brenders (1981) describe Roman relics from this period in The Netherlands like Corbulogracht (*Fig. 84*).

Approx. 600 AD: The sea first broke through in the North to create the Waddenzee and the Zuiderzee.

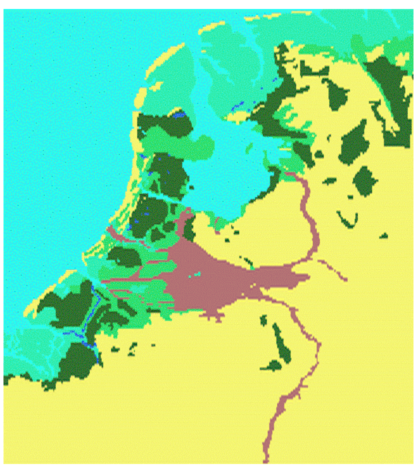


Fig. 83 The landscape of the Early Middle Ages, 600 AD[b]

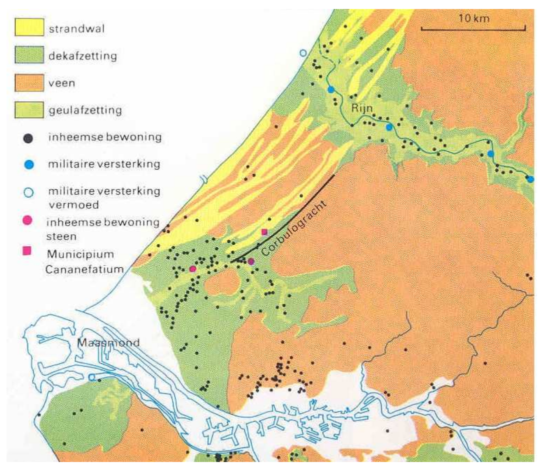


Fig. 84 Roman sites[c]

[a] University of Utrecht(1987), Vedel and Lange (1974)
[b] University of Utrecht
[c] Bloemers, Kooijmans et al. (1981) page 99

1.3.3 Seasons and common plants

Wetland and water

Few shoreline and water plants flower before may.

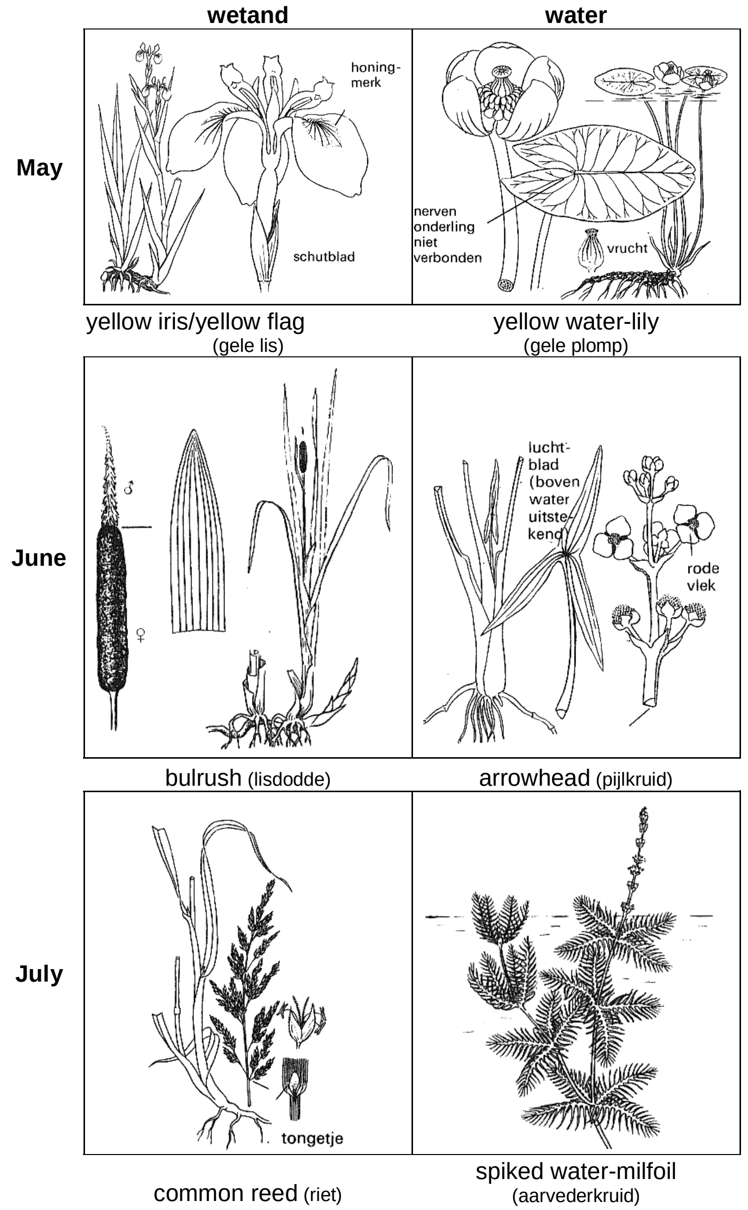


Fig. 85 Flowering periods wetland and water[a]

[a] Kelle and Sturm (1980)

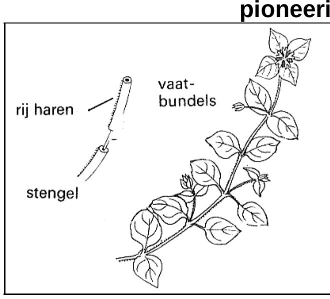
Disturbed and ruderal grounds

If one comes across pioneer vegetation in a certain season, then one can assume that the ground has been recently disturbed. If one comes across plants that grow on rough ground (ruderals), then one can assume that the soil was disturbed one or more years previously.
There are few plants growing on rough ground that flower before March.

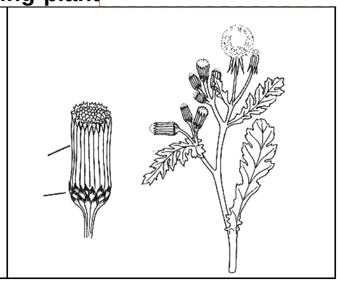
Comment [B5]: Page: 62
Bouwkundestudenten zijn niet geïnteresseerd in de op blz. 45 t/m 51 genoemde plantensoorten.

pioneering-plant | **ruderal**

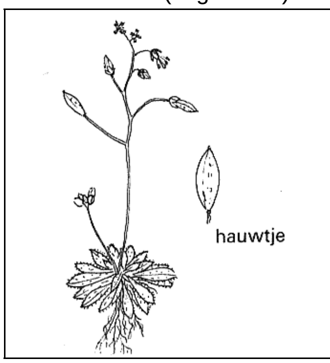
Jan



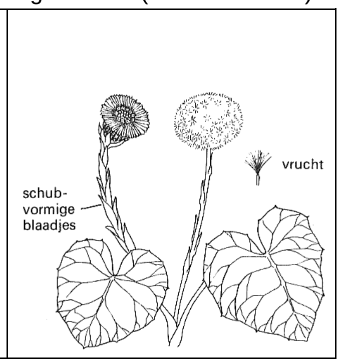
chickweed (vogelmuur)


groundsel (klein kruiskruid)

Feb

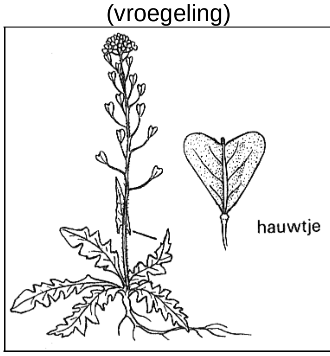


common whitlowgrass (vroegeling)

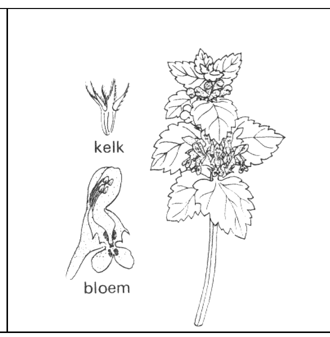


coltsfoot (klein hoefblad)

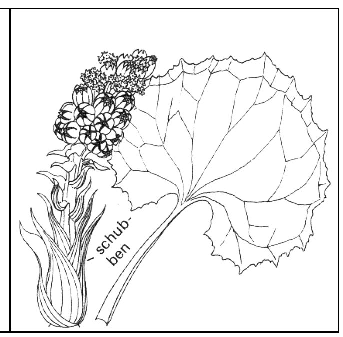
March



shepherd's-purse (herdertasje)



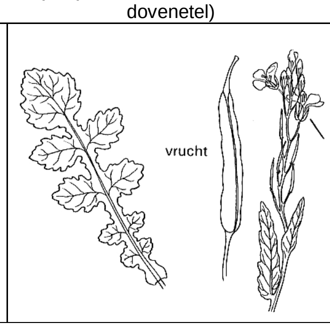
purple dead-nettle (paarse dovenetel)



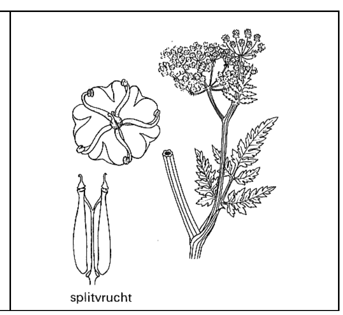
giant butterbur (groot hoefblad)

April

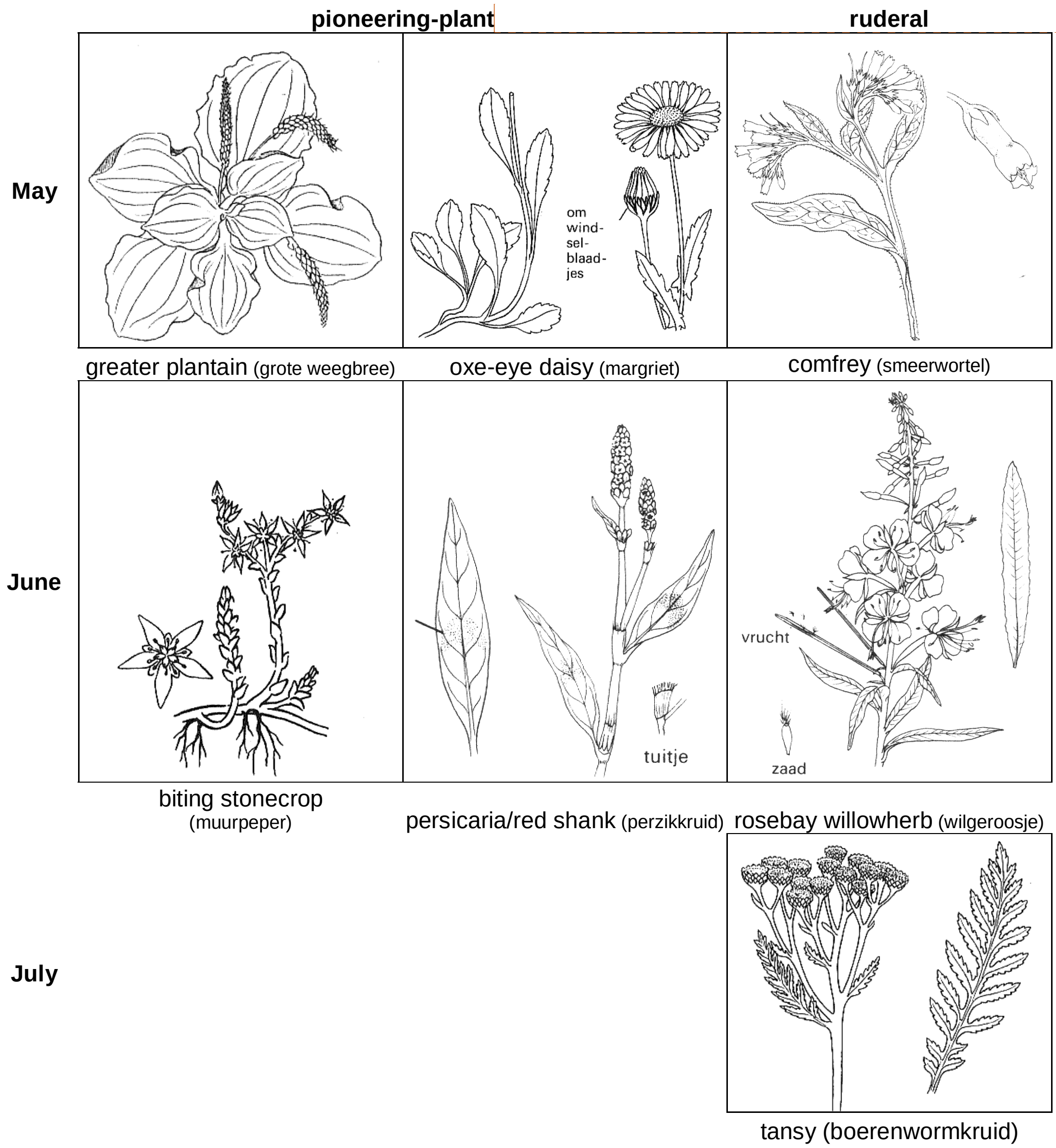

dandelion (paardebloem)



rape (koolzaad)



cow parsley (fluitekruid)



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Bouwkundestudenten zijn niet geïnteresseerd in de op blz. 45 t/m 51 genoemde plantensoorten.

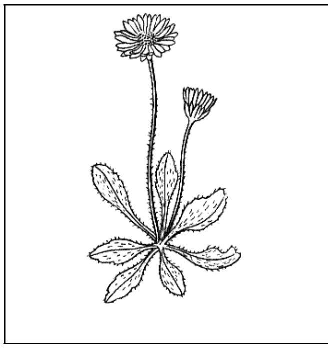
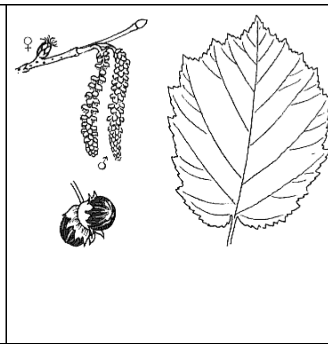
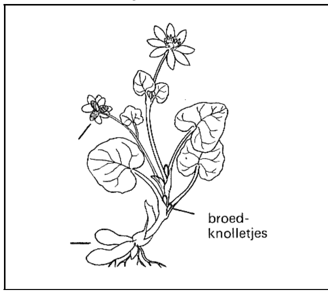
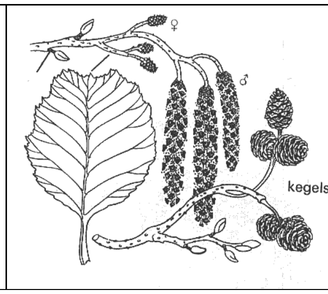
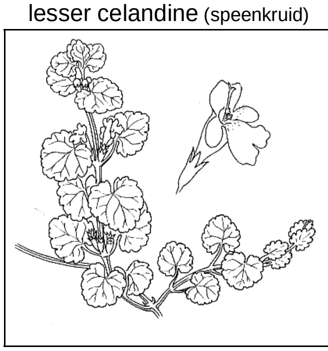
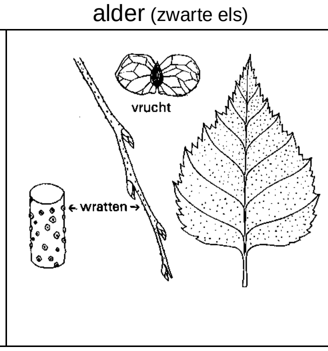
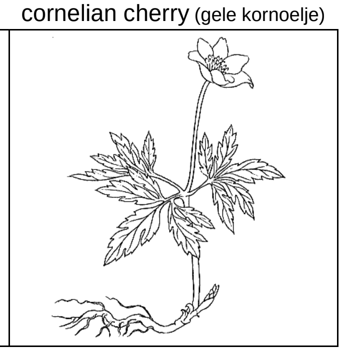
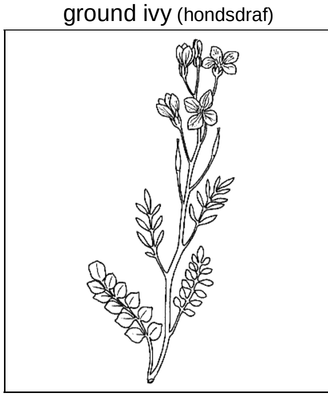
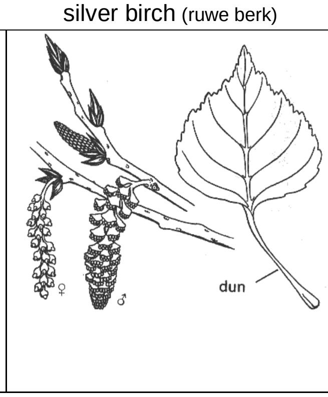
Fig. 86 Flowering times pioneers and ruderals[a]

There are few pioneering plants that begin to flower after June.

[a] Kelle and Sturm (1980)

Grassland and forest

If one encounters woodland vegetation, then the soil has remained undisturbed for a longer time.

	grass land	wood/forest	
Jan			
	daisy (madeliefje)	hazel (hazelaar)	snow drop (sneeuwklokje)
Feb			
	lesser celandine (speenkruid)	alder (zwarte els)	cornelian cherry (gele kornoelje)
March			
	ground ivy (hondsdraf)	silver birch (ruwe berk)	wood anenome (bosanemoon)
April			
	lady’s smock/ cuckooflower (pinksterbloem)	poplar (populier)	broom (brem)

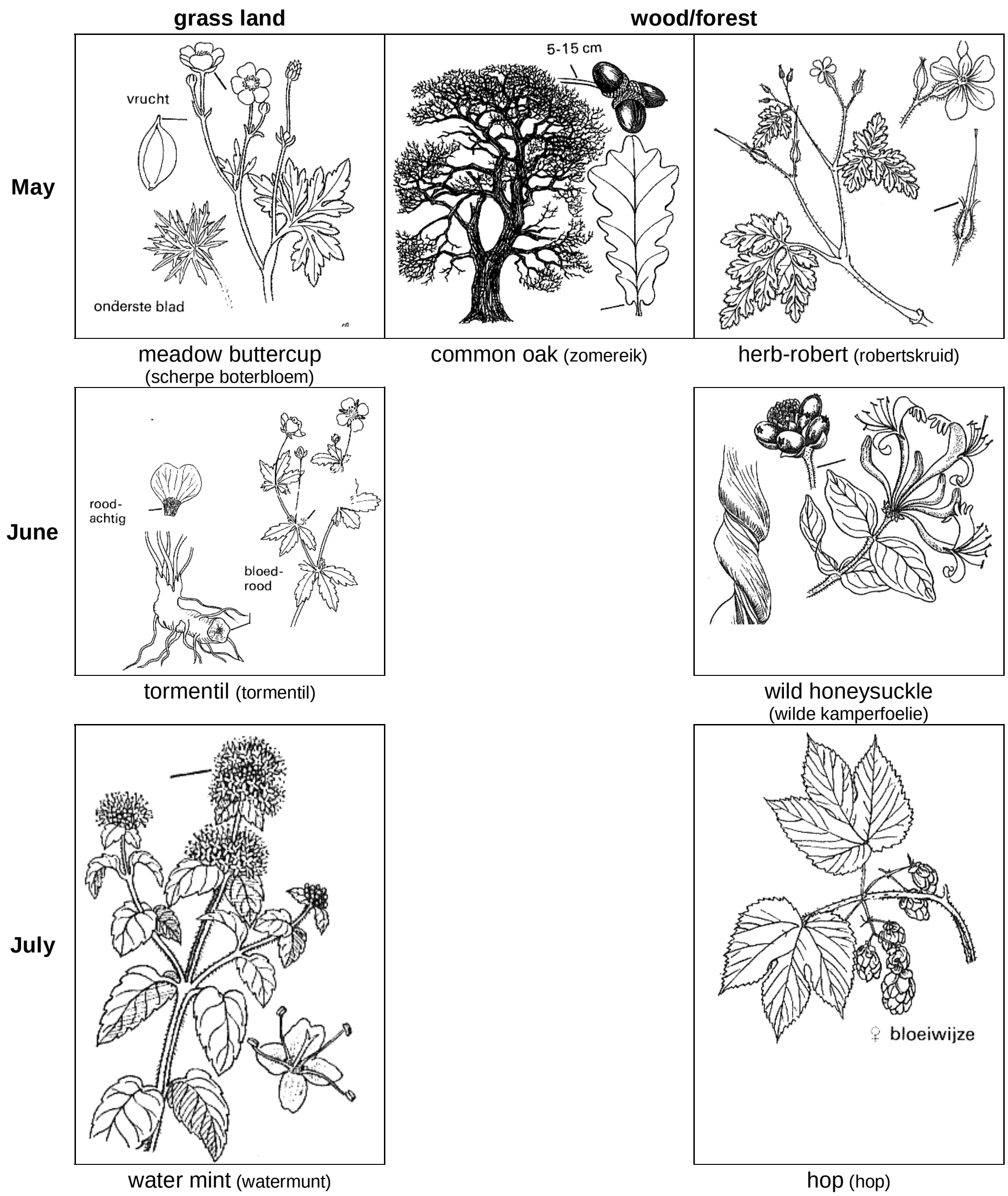


Fig. 87 Flowering times on grass land and in forest[a]

Few trees flower after May.[31 32]

[a] Kelle and Sturm (1980)

Mowing Grasslands

Grassland plants indicate frequent mowing, however, from the nature of grassland vegetation and on the basis of the above table, one should be cautious to mow in flowering periods if you do not want to disturb animals like butterflies.[33]

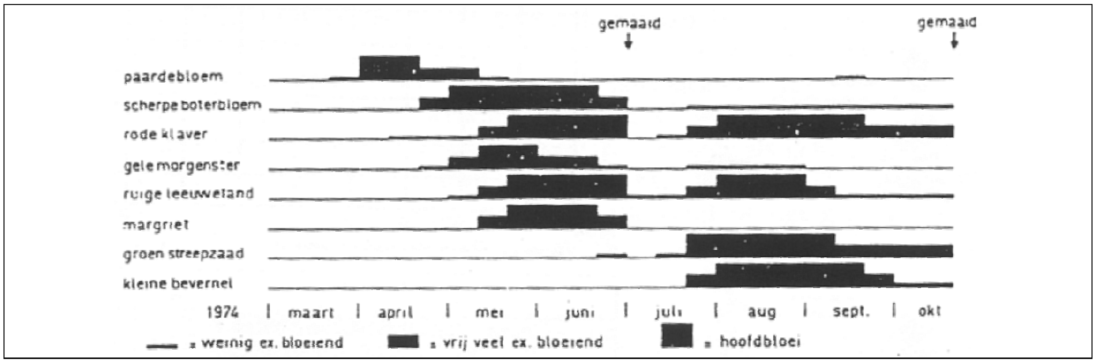


Fig. 88 The effect of mowing on various species[a]

Some species show a second flowering period after mowing.

Mowing to remove minerals

On poor soils one encounters special plants in greater diversity than on rich soils. There, they are pushed aside by very common species like stinging nettle (brandnetel).
For more than 10 years already there has been a mowing policy in Zoetermeer that is directed towards ensuring that the food content of roadside vegetation is drastically reduced by regularly removing biomass:

Aantal soorten				Maaibeheer	
Tak	1982	1988	Verschil (%)	Freq.	Tijdvak
Afrikaweg	107	118	+9	1	2e helft augustus
Amerikaweg	96	124	+23	2	2e helft juli/2e helft sept.
Australiëweg	112	141	+21	1	1e helft sept.
Aziëweg	102	112	+9	2	2e helft juni/2e helft sept.
Aziëweg, natte middenberm[1]	83	76	- 9	1	2e helft sept.
Oostweg	111	139	+20	2	2e helft juli/2e helft sept.
Europaweg[2]	—	42	—	2	2e helft juni/2e helft sept.

Het totale aantal soorten over de het hele hoofdwegennet steeg in deze periode met ±10% van 200 naar 222.
1) De brede, natte middenberm van de Aziëweg is in deze periode van een drainage voorzien.
2) De Europaweg was in 1982 nog niet aangelegd.

Fig. 89 Mowing management in Zoetermeer[b]

Over a period of 10 years, impoverishing the soil does not appear to lead to a large increase in the number of species growing there. Obviously, more time is needed for this to happen.

[a] Londo (1987) page 103
[b] Vos (1990)

1.4 Planting by man

1.4.1 Introduction

The key thing to remember when designing and using planting elements is that you are dealing with living material.[34] Architects work with dead material; buildings are not living organisms. Trees grow, and young trees have a form, different from mature trees. They look different in winter and change under the influence of climatic conditions. A plane tree, for example, has a pyramidal form when young and then 'sags' when older. Trees attain their typical growth form when they are 15 to 20 years old and keep it until they are 80, but by then they will have acquired an individual 'character'. Shrubs usually achieve their mature form after about 10 years. Perennials and roses reach maturity in just 2 to 3 years.

Planting effects

The following illustrations give an impression of the wealth of effects that can be achieved with planting.

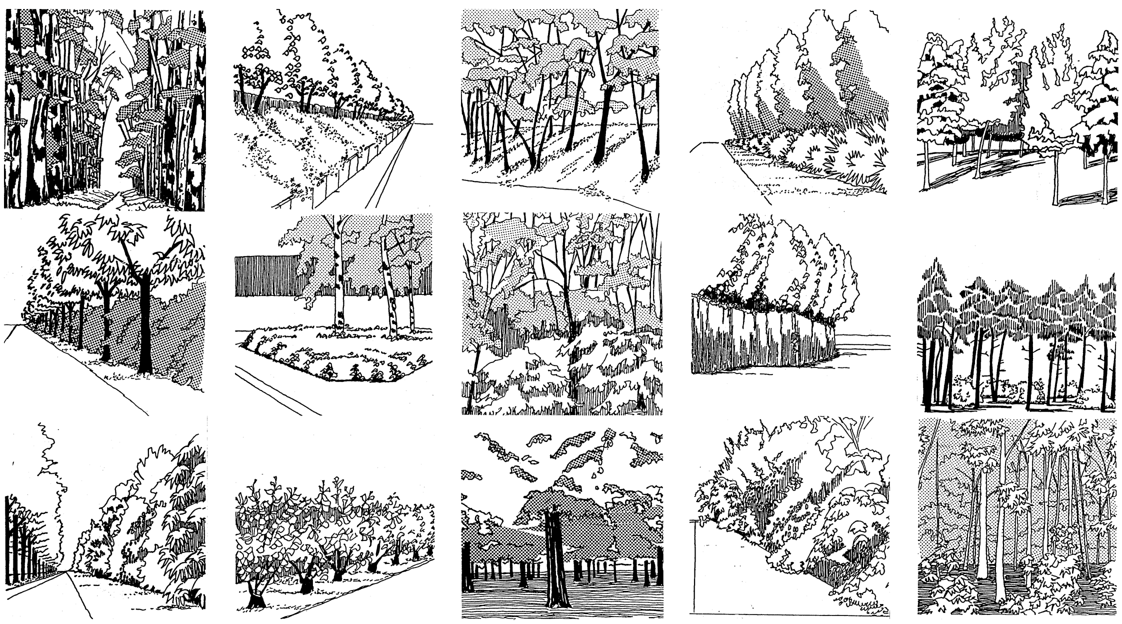


Fig. 90 *Visual effects of planting*

Conceptual framework

Introduction

The conceptual framework is a language to express and convey planting effects. To describe a particular effect we can draw from the themes and related visual forms described below. The overall effect. Depends on the role of each theme.

Themes

The degree of screening[35]
Height is an important consideration when deciding on planting elements. Their height determines how much of the objects behind the planting can be seen. The degree to which they are hidden is called the degree of screening.

The degree of transparency
The visibility of objects behind the planting also depends on how much can be seen through the planting. This is referred to as the degree of transparency.

The degree of uniformity
When looking at a planting element we can examine the diversity of species in relation to the height of the composition to determine vertical variation in texture.

The degree of continuity
In the same way, the diversity of species along the length of the planting element can be examined. The horizontal variation in texture is important.

Structure[36]
The manner in which trees and shrubs are placed to create a unified composition has a strong influence on the other themes. Structure plays a major role in creating the overall effect.

Edge profile
In urban areas planting elements are usually narrow and consist, essentially, of two edges. The profile of these edges has a major influence on the appearance of planting elements.

The degree of naturalness
The mood or atmosphere created depends to an important extent on whether the composition has a formal, artificial appearance or an informal, 'natural' feel.

Characteristic Forms

Each theme can manifest itself in different ways characteristic forms. These can be clearly indicated by introducing terms for all the possible forms.

The degree of screening

Fig. 91 *Edge: maximum planting height 0.5m*

Fig. 92 *Articulation: planting height between 0.5 and 1.5 m*

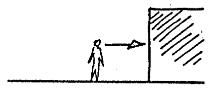


Fig. 93 *Partition: planting height between 2 and 5 m*

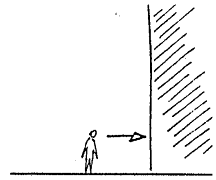


Fig. 94 *Screening: planting is higher than 5 m*

The degree of transparency

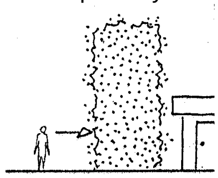


Fig. 95 *Wall: the planting blocks all vision*

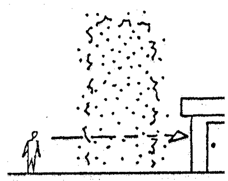


Fig. 96 *Curtain: even, partial visibility through the planting*

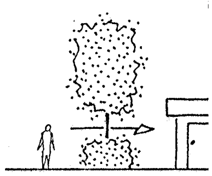


Fig. 97 *Window: opening in the planting*

The degree of uniformity

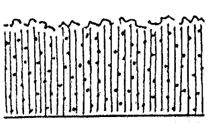


Fig. 98 *Even: no clear vertical variation in texture*

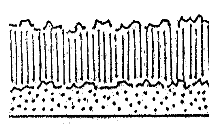


Fig. 99 *Layered: clear vertical variation in texture*

The degree of continuity

Fig. 100 *Constant: no horizontal differences in texture*

Fig. 101 *Rhythm: differences in texture at regular intervals*

Fig. 102 *Accentuation: random striking differences in texture*

Edge profile

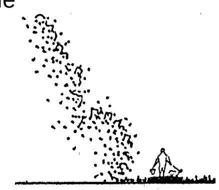


Fig. 103 *Receding*

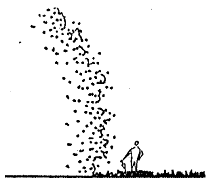


Fig. 104 *Upright*

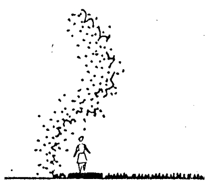


Fig. 105 *Overhanging*

Degree of naturalness

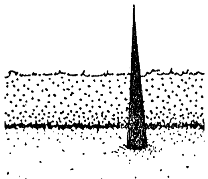


Fig. 106 *Straight and 'hard': the planting has straight contours and 'hard' boundaries*

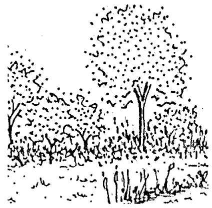


Fig. 107 *Ragged and 'soft': the planting has irregular contours and vague edges*

Structure

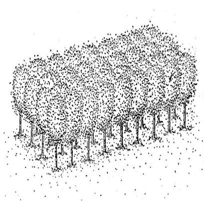


Fig. 108 *Trees*

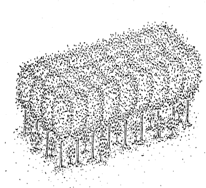


Fig. 109 *Trees with occasional shrubs*

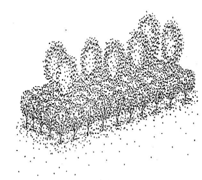


Fig. 110 *Shrubs with occasional trees*

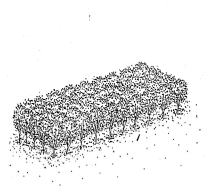


Fig. 111 *Shrubs*

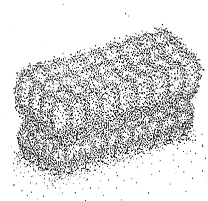


Fig. 112 *Trees with a shrub margin*

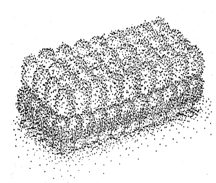


Fig. 113 *Trees with a shrub layer*

Design tools

Comment [B6]: Page: 73 Blz. 59, 60 Section)???

Each of the characteristic forms described above can be created using different design tools:

Edge
- Native stock trimmed to form a hedge
- Low-growing non-native plants

Articulation
- Native stock trimmed to form a hedge
- Smaller, non-native shrubs

Partition
- Native shrubs with or without trimmed edges
- Larger non-native shrubs

Screening
- Tree planting, no crown raising
- Tree planting with shrub layer; the trees and shrubs must intertwine

Wall
- Native species with a dense, compact habit
- Non-native evergreen species
- Wide spacing and sufficient thinning to allow full growth and the development of complete foliage cover
- No crown thinning, branch reduction or crown raising
- Broad plant bed

Curtain
- Species with an open and loose habit
- Small distances between plants, which encourages them to grow upwards
- Crown thinning, branch reduction and crown raising is possible
- Narrow plant bed

Window
- Native shrubs pruned to the right height
- Low, non-native shrubs
- Widely spaced shrubs for full growth and good foliage cover
- Trees with upright crowns
- Trees with raised crowns

Even
- Large number of species, individually mixed
- Small number of species with very similar textures
- One species

Layered
- A few layers with very different textures
- Each layer consists of one species or a few species with very similar textures

Constant
- In species-rich planting the length of the planting element must be many times its height (minimum 100 m)

Rhythm
- Striking individual trees or shrubs planted at regular intervals

Accentuation
- Striking individual trees or shrubs at irregular intervals

Receding
- Free growth along the edge
- Shrub margin in front of tree planting

Upright
- Use of woodland planting as hedge
- Tree planting with low branching crowns

Overhanging
- Edge pruning in a margin of trees and shrubs
- Crown raising in an margin containing only trees

Straight and hard
- Pruning for shape
- Straight, clearly defined edges
- Rhythmic or striking accentuation along the edge
- A sharp silhouette
- Layered

Ragged and soft
- Vague, ill-defined edges; abundant herbs in the edge
- Individual mixing of striking species
- Ragged silhouette

The effect over time

Planting schemes can be grouped according to the way they develop from the time of planting until they reach full maturity.

The first group consists of planting schemes with a pronounced static character. Stated simply, the effect of such planting schemes changes little over time, they just become higher and fuller. These planting schemes are simple, containing just a few species which each have a clear place and contribute to the overall long-term effect.
In contrast, the second group consists of planting schemes with a distinctly dynamic character. A typical example is traditional woodland planting schemes: species-rich, individually mixed planting. The roles of the individual species constantly change, creating a succession of visual effects over time.[37]

The final group of planting schemes are those with a cyclical development. The visual effect is obtained by periodic rigorous pruning back to restore the same visual effect.

Design techniques

Each of the planting groups described above can be linked to a number of specific design techniques to choose from.

Static planting

- The structure of the planting and the role played by each species in the visual effect is determined beforehand.
- The way the visual effect will develop is clear from the start; specific maintenance work will need at certain times to achieve this effect.
- When the planting has reached maturity the purpose of maintenance work is to maintain vitality and a tidy appearance.
- Radical rejuvenation measures are delayed as long as possible.
- The 'nurse crop' system cannot be used.[a]
- Use of long-lived species.
- Rows of different species.

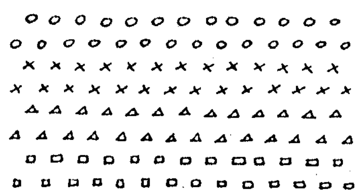


Fig. 114 *Static planting technique*

Dynamic planting

- Indicate the characteristic forms that will determine the appearance of the planting (e.g. transparency)The structure of the planting and the role of each species in creating the visual effect are not fixed in advance. During the growth of the planting there are certain moments when the designer and technical maintenance staff have to decide how the planting scheme will continue to develop. The choice is influenced by the previous visual forms.
- The 'nurse crop' system can be used.
- Plants may be individually mixed.
- Species with different life cycles may be mixed together, although this makes maintenance more complex and expensive. The most manageable system is to keep to the life cycle of the main plants.
- The plant bed must be at least 50 m wide; any narrower and it is extremely difficult to manage the visual effect. The planting will acquire a ragged appearance with, in places, considerable differences in height, texture and transparency.

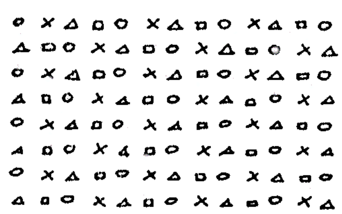


Fig. 115 *Dynamic planting technique*

[a] In this system the planting mixture contains a number of species which grow faster than the permanent species. Their function is to protect the main planting during the initial years of growth and are removed after a number of years (see § 0)

Cyclical planting

- The appearance of the planting is fixed beforehand.
- The desired appearance develops too quickly but is repeated; the effect is dominated by periodically cutting back to just above ground level.
- The timing of pruning is based on the fastest growers – depending on their rate of growth, once every three to seven years.
- The 'nurse crop' system cannot be used.
- Only species amenable to hard pruning can be used.
- A wide range of species can be used because species do not have the chance to suppress other species.

Restrictions on the choice of plant material

Both the nature of the plant material and the environment in which it is planted impose a number of limitations. If these limitations are not properly taken into account in the design, the desired visual effect will not be achieved.

The range of influential factors can be divided into two groups:[38]

- The characteristics of the plant material itself, called 'iron laws'.
- Environmental influences, in this case the urban environment.

Iron laws

Introduction

The native species available for planting differ widely in two respects:

- Light requirement
- Rate of growth

These differences drive two processes that are always at work in woodland planting schemes:

- The natural process of forming open spaces in woodland
- Process of species supressing other species

Because these processes always occur they are often called referred to as 'iron laws'.

The natural process of forming open spaces in woodland

Under natural conditions, herbs are in time overgrown by shrubs, which in turn are eventually shaded out by trees. The planting 'hollows out', as it were, from the middle. Eventually, the middle of the planting area will consist mainly of trees; shrubs can maintain themselves only along the edges. What develops is, in effect, a natural woodland profile. This process repeats itself when trees die and fall. In the open spaces where sunlight reaches the ground, herbs spring up again, only to be overgrown by shrubs, etc.

This profile does not develop in artificial urban environments because the plant beds are usually far too narrow. This means that in urban areas 'woodland planting' based on this natural process can only contain a segment of the natural profile of the woodland edge. There are a number of possibilities:

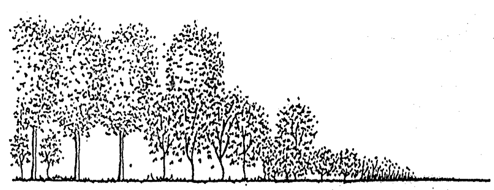


Fig. 116 *Woodland profile*

These are called ‘planting forms’ – in effect, no more than combinations of trees and shrubs derived from the natural woodland edge.

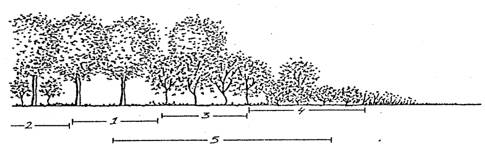


Fig. 117 *Planting forms*

If the process is not the basis of the design, a further option can be added to the list:

In such a planting scheme the process must be continually checked, which requires intensive maintenance. The appearance easily degrades if maintenance work is not carried out on time.

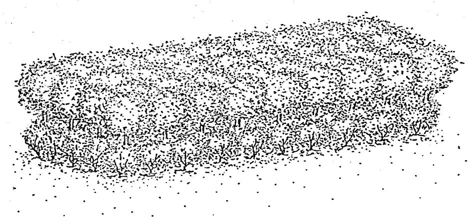


Fig. 118 *Tree layer with a shrub layer*

Each of the planting forms has specific planting and maintenance requirements. These are listed below.

Tree layer

Dimensions:
- minimum width of the plant bed: 15 metres
- in narrower compartments one or two rows of nursery-grown standard trees

Fig. 119 *Tree layer*

Tree layer with occasional shrubs

In addition to the recommendations for the tree layer above:
- the shrubs must tolerate shade
- the trees must cast as little shade as possible

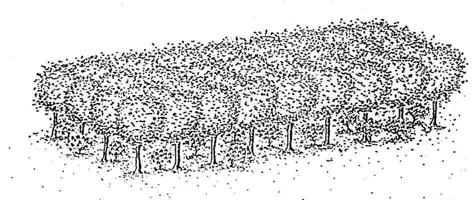


Fig. 120 *the tree layer with occasional shrubs*

Shrub planting

Giving each shrub less space encourages rapid vertical growth. Constraining horizontal growth, though, usually reduces the robustness of each individual shrub.

Fig. 121 *Shrub planting*

Shrub planting with occasional trees

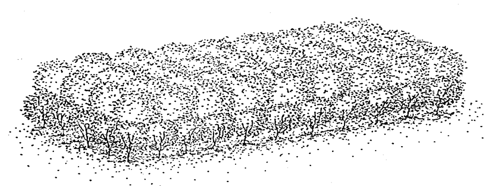
- the trees should cast little shade
- trees should be nursery-grown standards

planted at least 20 metres or more apart
the shrubs must grow more slowly than the trees

Fig. 122 *Shrub planting with occasional trees*

Tree planting with a shrub margin

The recommendations made for the tree layer and for shrub planting apply here; tree planting with a shrub margin is actually these two forms joined together. Again, some additional recommendations can be made:



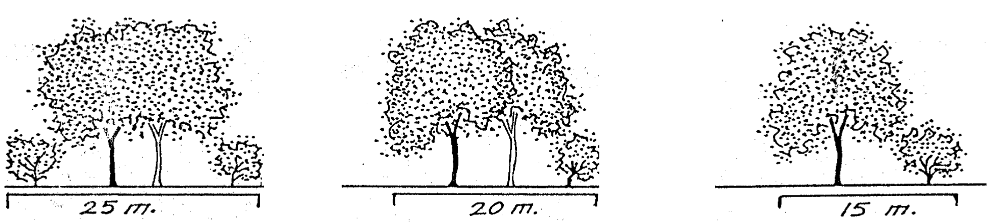


Fig. 123 *Tree planting with a shrub margin*

Dimensions
- minimum width of the plant bed for a symmetrical profile: 25 metres
- minimum width of the plant bed for an asymmetrical profile: 20 metres
- 15 metres is sufficient width for a row of nursery-grown standard trees and a row of nursery-grown shrubs

Plant selection and situation
- sun-loving shrubs can only be planted on open south-facing sites
- a continuous strip of shrubs on north-facing edges is not possible: only a few dispersed shade-tolerant shrubs will be able to survive
- eastern and western edges should be planted with shade-tolerant shrubs

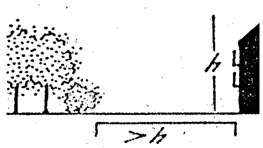


Fig. 124 *This is necessary to ensure sufficient daylight penetration*

Process of species suppression by other species

The environment into which new plants are put (bare soil) is ideal for pioneer species[a] However, planting schemes often involve planting pioneer species and climax species[a] in the same bed. The pioneer species thrive in this environment and soon outgrow the climax species.

We can deal with this in different ways:

- accept the suppression of species
- prevent the suppression of species

Working against the suppression of species is not really possible. Maintaining a rich mixture of pioneer and climax species 'whatever the cost' involves a considerable amount of work. The visual effect is highly vulnerable to any delays in maintenance work.

Accepting the suppression of species

When some slow-growing species have only a temporary role to play in the visual effect, the suppression of species presents no problems. When the planting is still young these species can maintain themselves without difficulty and enhance the appearance of the planting for a while. When the plants grow up they are eventually suppressed and the fast growing species dominate.

This means that:

- the appearance of the planting changes quite a lot during its development, in a sequence of intermediary forms
- this planting type requires relatively little maintenance

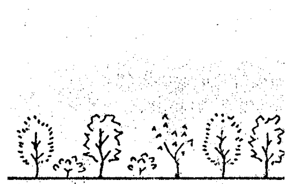


Fig. 125 *Intitial species*

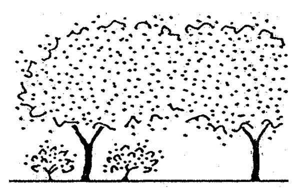


Fig. 126 *suppressed later*

Preventing the suppression of species

If a limited number (1 to 3) of species with the same growth rate are planted none of them will be suppressed.

This means that:

- the appearance of the planting changes little over time
- such planting schemes require relatively little maintenance During its development each species plays the same role in the overall effect.

[a] These are terms from plant ecology and relate to the changes a natural vegetation goes through in the course of time, the succession.

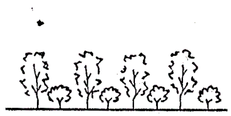


Fig. 127 *Small number of species*

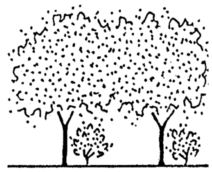


Fig. 128 *not suppressed later*

Artificial succession

A totally different way of dealing with different growth rates is to use the nurse crop system. Pioneer and climax species are planted together, the pioneers (the nurse crop) protect the climax species when they are young. Once the pioneers have fulfilled their function they are cut, allowing the climax species to develop further.

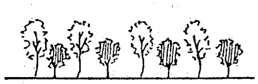


Fig. 129 Nurse crop

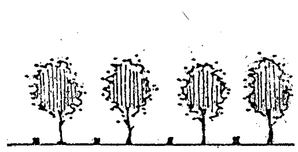


Fig. 130 removed

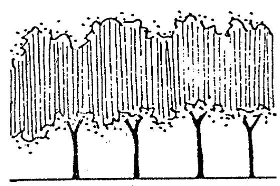


Fig. 131 leaves climax species

This approach means:
- the appearance of the planting changes considerably and suddenly over time; in effect there are two stages, each with its own appearance
- this type of planting requires a relatively high level of maintenance
- the appearance degrades if maintenance falls behind schedule

Urban areas

Introduction

Besides the influences of the plants themselves, the influences of the physical environment surrounding the planting also play a role: in this case, the urban environment.

Data on a number of these factors are available, for example on:
- the soil (profile, mineral composition, organic matter content)
- water management regime
- traffic engineering requirements (sightlines)
- mains services, cables and pipes
- building control (distance to outer wall)
- pollution (exhaust gases, road salt)
- gusts and downdraughts

A few important aspects are discussed below. These are:
- the limited space
- the limited amount of daylight
- informal use (wear and tear)

Limited space

It is only really the width of a plant bed that sets firm limitations on the use of woodland planting in urban areas. The plots in urban areas are often too narrow. Native species in particular need plenty of horizontal space to grow freely. Shrubs can easily achieve a diameter of 5 meters and the crowns of the biggest trees can be as much as 10 metres across or more, given time.

The minimum width of a pant bed must be greater than the width of a spreading shrub because after woodland planting has been thinned the margin will never consist of a straight row of plants.

Minimum width of the plant bed

- Shrubs in woodland planting require a plot at least 6 metres wide.
- A woodland planting that includes trees requires a plot at least 15 metres wide.

Plant beds narrower than 6 metres wide

- Only suitable for woodland planting if at a later stage the margins are continually cut back or pruned.
- Straight row of nursery-grown shrubs or trees.
- The required width can then be reduced to 5 metres. If the margins are also cut back the plot may be even narrower.
- Non-native species with a narrower growth form.

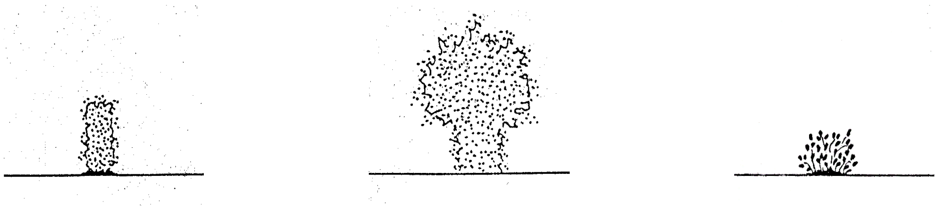


Fig. 132 *Plant beds narrower than 6 metres wide*

Besides a sufficiently wide plant bed, a generous margin is needed if plants are to grow freely and reach their full width.

Edges

On edges you should leave space for later development.

Fig. 133 *Leaving space*

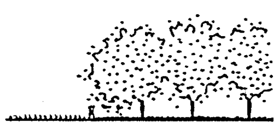


Fig. 134 *for later*

Another possibility is to plant up the whole plot and remove the outside row at the first thinning.

An unplanted strip should be left along the margin of the plant bed. This can be temporarily filled with grass, herbs or ground cover plants.

Fig. 135 *Initial planting*

Fig. 136 *thinning*

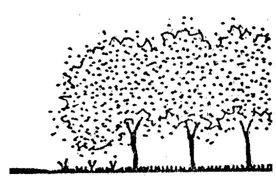


Fig. 137 *for growth*

The stems of the shrubs in the outside row should be no less than 2.5 metres from the edge of the plant bed

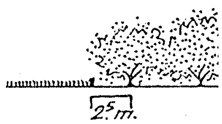


Fig. 138 *Shrub distance*

When trees are included in the planting they should be at least 5 metres from the edge of the plant bed.

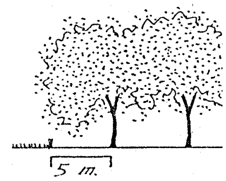


Fig. 139 *Tree distance*

Planting patterns

A regular pattern of rows is the most preferred option for the long narrow plots usually found in urban areas; it permits mechanised planting and hoeing and systematic thinning.

An irregular pattern requires more complex maintenance and makes the visual effect more difficult to control; in narrow plots the planting can easily take on a patchy appearance.

Rows can either be planted to form a square or triangular grid; an important feature of the triangular pattern is that after the first systematic thinning the remaining plants are equal distances apart, which is highly beneficial for their subsequent development.

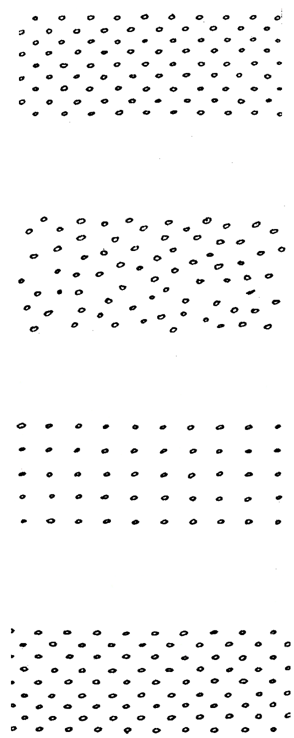


Fig. 140 *Planting patterns*

Limited daylight penetration

The way the edges of the planting develop is heavily influenced by the amount of light. Two aspects play a role here:

The orientation of the edge in relation to the sun.
The location of any nearby objects; other planting and buildings often cut out a lot of light.

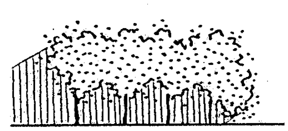


Fig. 141 *Sunlight orientation*

We can deal with these effects in various ways:

- Appreciate the positive aspects of the differences between margins resulting from differences in daylight penetration.
  For example, the differences between a north-facing edge and a south-facing edge can be seen as a special feature. On the shaded side you can look between the stems into the planting; in the background the sunlight filters through the foliage on the other side in a soft green haze. On the sunny side you look at a dense mat of foliage; a few small patches of the darkness beyond are occasionally visible.

- Give all edges the same profile through the careful choice of species.
  If the aim is to ensure a good edging with shrubs, species will have to be planted along the eastern and western edges different from those along the southern or northern edges.

- Careful siting of plants in relation to nearby objects[39].

Fig. 142 *Siting of plants*

  - Trees and shrubs can become straggly and thin if the distance between the plant bed and a nearby object is less than the height of that object.
  - Spreading, well formed trees and shrubs and a dense margin can develop where the distance between the plant bed and a nearby object is greater than the height of that object.

Informal use (wear and tear)

Plants in urban areas are exposed to heavy use. Paths may be worn by people walking through planting elements and children may play in them.

Such wear and tear can be resisted. This is often desirable for planting elements in semi-public spaces, such as residential courts, where residents can exert informal social control to prevent damage to planted areas. Narrower strips of planting are particularly vulnerable and the survival of the whole planting element could be at risk.

- Preventing informal use
  - The first step is to locate the planting element with sufficient care: study the walking routes and level of use in general; maybe even cancel the planting altogether.
  - Plant species that are hard to walk through, such as thorny bushes, but do not forget that these can severely hamper maintenance work and are not suitable near schools or playgrounds.
  - Another option is to add exotic species to the woodland mix. These give the planting a more graceful appearance which can evoke greater respect from the public, particularly if they feel attached to the area.

Instead of preventing informal use there may be opportunities to make use of it. This may be possible in planting with a clear public function in a more anonymous location. In such places, informal use of planting elements can enrich the functional value of the public domain. Moreover, planting areas in public spaces are usually larger and so informal use is no threat to the survival of the planting element as a whole. Plots accessible to the public must be at least 25 to 30 metres wide (deep).

- Accepting informal use
  - When managing a *fait accompli*, e.g. surfacing a short cut worn through regular use, the special qualities (e.g. a certain sense of secrecy) of cutting through the vegetation is destroyed.
  - Not replanting open spots in the planting.
  - Use species that are resilient to wear and tear.
  - Opportunities can be created, for example by tipping a pile of sand in the planting area so that children can make a mountain bike arena.

1.4.2 Planting and Habitat

Factors

The suitability of planting depends on climatological conditions (wind, light, seasons)[40] and physical conditions (soil, groundwater level, air and the space available above and below ground). A different selection of plants is needed behind the dunes along the coast than on a site in a fenland polder or on the sandy soils of Noord-Brabant.
As a designer, you will at first be tempted to base your choice of plants on spatial qualities to do with dimension, form (habit), colour and structure. A further consideration is whether the site is in a rural or an urban environment, where there are special restrictions.

Whatever the scale at which you are working, the final detailing is crucial. Financial resources will often be an important consideration (particularly if planting or transplanting older trees is involved).

Climatological conditions

Wind

Wind, usually from the sea, is an important factor in the west and north of the Netherlands; frost in the east and south. The effects of wind must be fully considered as it exerts considerable pressure on twigs and branches (in leaf). In rural areas, the direction of the prevailing wind can often be read from the shape of the trees.

Poplars grow rapidly and quickly make a spatial impact, but are ‘not solid enough’. At about 40, branches tend to split and so many trees are felled at around this age. Poplars are not the trees to plant if you want them to be around in 100 years time, although they can live for a long time. As solitaires, it may be worth the extra work, but not for an avenue.

Unfortunately, many a good tree succumbs to our autumn storms; the poorest specimens have by then lost their leaves, but those that still have a good leaf cover are exposed to the full force of the wind.

But wind is not restricted to rural areas. The taller buildings built in recent years create considerable ‘downdraughts’. In front of the Robeco building in Rotterdam some trees have been planted to absorb these downward gusts so that passing cyclists are not literally blown through the air! Climatological conditions, therefore, do play a role in urban planting.

Light

Light pollution (albeit only at high levels) and salt (road salting in winter, fish stalls on the market) are disastrous for trees. Light requirement and ‘drip damage’ are more important factors affecting shrubs, and trees with dense crowns permit only a very little undergrowth. The so-called ‘woodland planting’ (plots with trees and shrubs) dating from the 1970s often cause problems now. The trees are large and the undergrowth is dying off purely due to insufficient light. Of the original large plots full of trees and shrubs, only the edges will eventually remain, the planting being hollow under the tree canopy in the middle. If you want the shrubs top remain, plant the trees far apart or choose trees with open crowns that let a lot of light through. ‘Drip damage’ can be a significant problem; some hedges (e.g. Yew) are very susceptible to drip damage, other, like Beech or Sycamore, are unaffected.

Seasons

Planting should look attractive the whole year round. Some trees and plants bloom in winter. Autumn colouration can also add variety.

Spring (flowering)[41]

- trees: alder and willow (March); cherry and magnolia (april); apple, horse chestnut, hawthorn (may)
- Shrubs: hamamelis, forsythia (March); currant, rhododendron (April); azalea (May)
- bulbs/tubers:
- early: (February/March): snowdrop, crocus
- late: (April/May): narcissus, tulip

Summer[42]

- trees: horse chestnut, catalpa (july); golden rain (June)
- shrubs: hibiscus, hydrangea, roses and perennials

Autumn (colours)[43]

- trees: sycamore, birch, hornbeam, sweet chestnut, hawthorn, honey-locust, oak
- shrubs: whitebeam, currant, spindle

Winter

- berries: hawthorn, privet, ornamental apple
- evergreen shrubs: rhododendron, holly, viburnum
- shrubs with berries: currant, whitebeam, ivy, privet, rose

Winter (flowering)[44]

- tree: *prunus subhirtella* ‘autumnalis’ (flowers November/December and again in April)

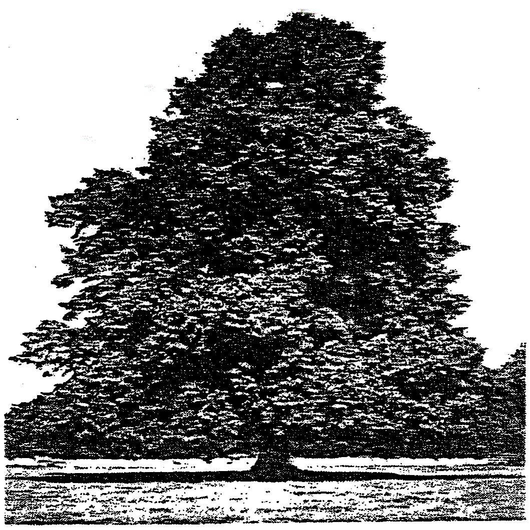


Fig. 143 *Lime (summer)*

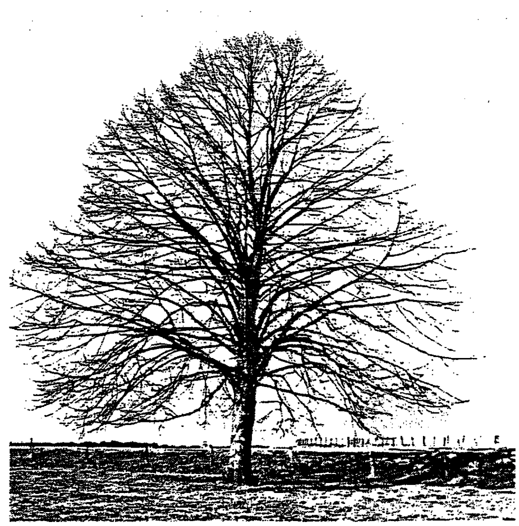


Fig. 144 *Lime (winter)*

Physical conditions

Pysical conditions concern soil, groundwater, air and space for roots.[45]

Soil

Roughly speaking, soil in the Netherlands can be classified into clay, peat and sandy soils (and all the intermediary forms). Plants on sandy soils – often in windy locations – have adapted by reducing the size of their leaves (e.g. sea buckthorn, juniper), by growing hairs on their leaves (mullein) or by taking on light or greyish colours.

Examples of coastal trees:[46]

- alder
- poplar
- oak
- willow
- rowan

Because of their structure, clay and loamy soils retain water for a long time. They are often cold in spring, and less oxygen is available than in sandy soils.

Examples of trees on clay/loam soils:[47]

- alder
- horse chestnut
- birch
- cherry

Another important factor is the presence of calcium, which supports a different type of vegetation; a base-poor dune vegetation contains different plants to calcareous dune valley vegetation. Peaty areas are acid and always moist; nutrient levels are a crucial factor. alder and rowan do well in nutrient-rich peat, birch in nutrient-poor peat. Well-known shrubs suitable for acid soils are rhododendron and azalea. If they are planted in other soil types, peat will always have to be added to the soil.[48]

The above also applies, in principle, in rural areas, where plants still have a 'feel' for the soil. Clearly, in purely urban environments the original soil is less important for plants, particularly trees.

Sea clay
River clay
Peat
Sandy soils
Loamy soils

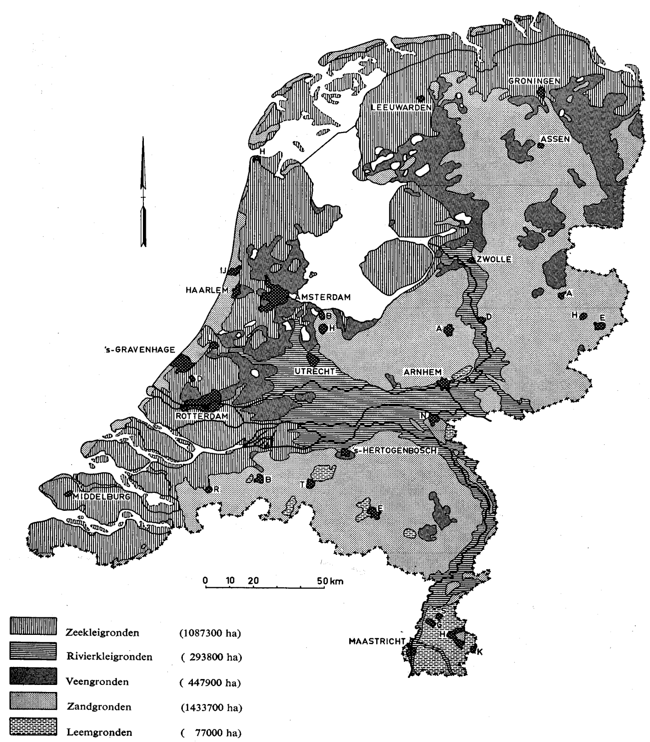


Fig. 145 *Soils of The Netherlands*

Groundwater

If the water table is too high, few trees and shrubs will be able to survive. Tree roots will develop poorly and not anchor the tree well in the ground; as a result they are easily blown over. Of course, too little groundwater is not good, either; the plants wilt.

Trees which can grow in wet conditions are: Alder, Birch, Poplar and Willow. [49]
Trees that can grow in dry conditions are a few Maple species, Birch, Hornbeam, Acacia and a few Poplar species. During the growing season (May to August) tress take up large quantities of water from the soil.

In an urban environment, trees depend on a number of sources of water:

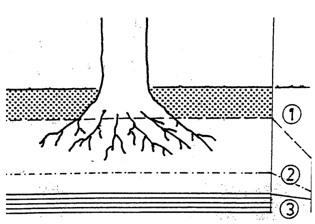
- Groundwater

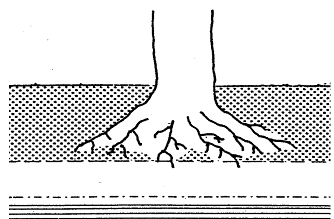
- Capillary water (‘sucked’ up from the groundwater through the soil)
- Pendular water (precipitation that clings to the surface of particles in the aerated zone)

The demand for water in summer is greater than the amount of pendular water. The extra is drawn from the groundwater; the water table falls in summer, but it is replenished again in winter from rain and snow.

Much water in the city goes straight into the sewer; the more ‘porous’ the paving is the better this is for the trees. But the water must remain for as long as possible in the pendular water zone. Humus is a valuable component in the soil because it retains a lot of water.

The best situation is a water table that fluctuates around 1.25 m under the soil surface (1.50 m in the summer and 1 m in the winter).[50] Under these conditions trees can become well established and firmly anchored. If a tree cannot take up enough water, the roots go in search of more. The root ball of a healthy tree reflects the size of the crown.





1. Soil containing humus
2. Capillary zone
3. Water table

Fig. 146 Spring

Fig. 147 Autumn

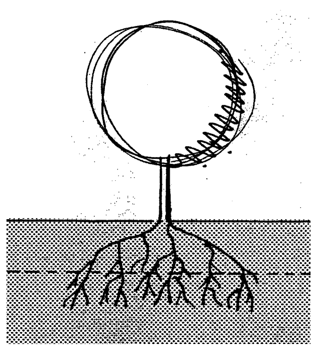


Fig. 148 *Groundwater level approx. 1.25 m:Roots and branches: above ground = below ground*

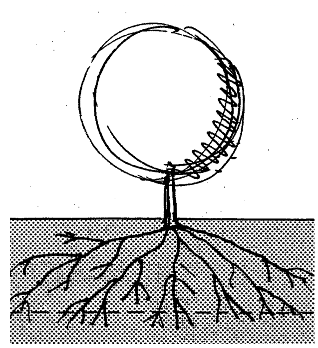


Fig. 149 *Deep groundwater level: roots ‘search out’ water*

Air

Trees in built-up areas – except trees in parks and gardens – grow in a habitat that simply cannot be compared with a site in a wood or open landscape. The soil in the country is open (to air and water) and fallen leaves provide a supply of nutrients. Conditions in urban areas are very different. Paving requires well compacted soil; but trees need open soils. Air is kept out by the closed road surface and compacted soil, which leaves almost no pore volume for air to penetrate.

In open soils, about 50% of the volume is air; below 15% oxygen, roots become stunted, at 11% oxygen they start to die. All paving seals the surface of the soil and so open spaces – slotted flags or widely spaced paving bricks – are essential. Trees cannot develop roots under asphalt surfaces (0% oxygen). The pressure and vibration caused by heavy traffic further compacts the soil.

In ‘sinking’ areas (peat soils) in the West of the Netherlands the paving has to be raised every so often, even up to 30 or more centimetres at a time. As a result, many trees receive too little oxygen and die. Oak and Beech always die, Lime trees grow a new layer of roots if the additional soil layer is no deeper than 25 to 30 cm. Elms and Planes tolerate these conditions quite well.[51]

A. Sinkhole
B. Sawn kerb, min. length 500
C. Kerb type Cru 80
D. Tree grille Cruquius concrete blue limestone colour 1200 x 1200 x 120
E. Air grate
F. Dark paving brick (size, 20x6.6x6)
G. Dark paving brick (Waal size, 20x5x7)

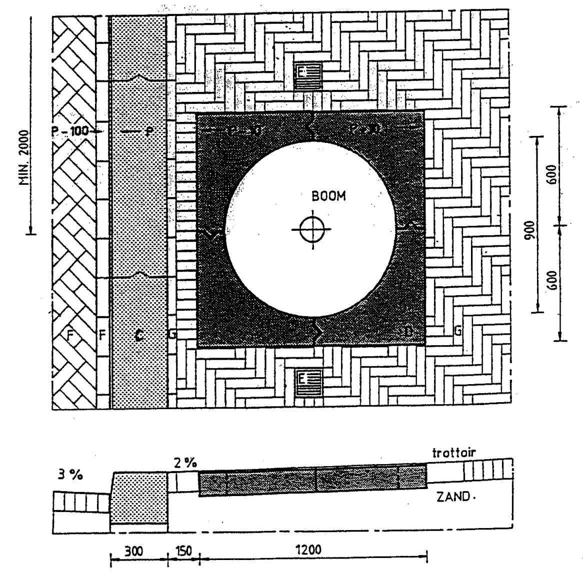


Fig. 150 *Tree pit*

Root corridor and tree pit

Urban trees cannot be viewed in isolation from their environment; they are one of the factors that define the public domain in the city. Street trees add to the quality of public spaces and have a different effect in each place. When planting trees in urban areas it is wise to design a strip for trees only, with no cars, cables and pipes or street furniture: a ‘corridor’. This ‘plantpit’ can be finished with a 10 cm layer of sand, with paving on top (with no risk that the paving will sink any faster than the surrounding area).[52]

If this is not possible, a tree pit of 2 x 2 x 1 m should be made and filled with suitable tree soil. Tree soil is light soil, contains approx. 4% humus, is well aerated and well drained, retains water well and contains sufficient nutrients. Where more air is required in the soil, perforated drainage pipes can be used as ‘air pipes’ to ensure better aeration of the soil.

In many places, though, hard road surfacing and numerous mains services and cables leave no room for planting. In these situations the minimum area required for a tree is 7.5 m on both sides (i.e. 15 m apart) because otherwise they will have an even greater struggle for survival. The more open the structure of the topsoil, the better this is for the tree.

It is important to choose a good tree grille. Square tree grilles are often used in paved areas because these fit well into the pattern of most paving materials. Cast iron or metal tree grilles are attractive, but expensive. Accumulation of dirt and rubbish in the space between the grille and the soil (approx. 10 cm) can be prevented by filling this space with Argex pellets until right under the grille. These are light, expanded clay granules (reddish brown) which considerably improve aeration. Another attractive solution is to use gravel. A cheaper option is 30 x 30 cm slotted flags. In parking areas always ensure that the tree trunk is protected.

Cross-section
Pavement
Tree corridor
Road / main sewer
Pavement / cables
and pipes

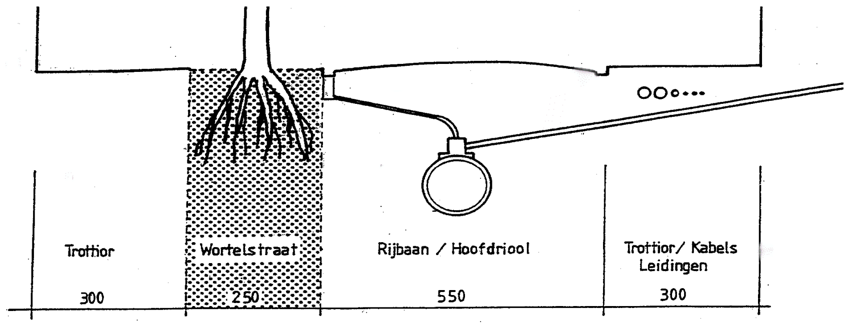


Fig. 151 *Cross-section*

Types of trees

Size, form, structure, colour

Size and form not only depend on climatological and physical factors, but also have a major impact on the streetscape. In spatial terms, they may or may not provide structure or accentuate the spatial composition (see Tree Structure Plan Amsterdam). Texture relates to the shape, size and arrangement of the leaves and it is very important when detailing to ensure compatibility with the materials used. Colour speaks for itself. A significant fact is that light green tints have the effect of expanding spaces, dark green and red-brown make spaces seem smaller and can create a sombre atmosphere. Copper-leaved trees are striking, particularly as solitaires, such as copper beeches on farms (also sycamore/maple, apple, cherry, oak).

Choosing a tree

When choosing trees, consider the amount of space above ground. If you meet the conditions discussed above (tree pit, soil, etc.) there is a chance that the trees will grow to maturity and attain their full size. Plane trees can easily have branches 10 m long, and so they should be planted 12 m from buildings. If the pavement is not very wide, choose a tree a size or two smaller or a tree with a columnar crown. If not, the crown will soon grow up against wall and must either be pruned each year, or the tree felled and another species planted.

Size classes of trees:[53]

- Size class 1: 15 m and taller
- Size class 2: to about 10 m
- Size class 3: to about 5 m

Size 1 trees develop crowns at least 15 metres across. Large dense crowns must be avoided in small streets, where trees with light open crowns are to be preferred (e.g. Gleditsia/Honey Locust). For most residents the minimum acceptable distance between crown and wall is about 2 metres. Obviously, planting distances will bear some relation to the location of the doorways, drives and passages along street frontages.

Planting distances

If trees are planted very close to buildings, drastic measures are repeatedly needed to ensure enough daylight penetration. Sometimes these measures can be so drastic that the resulting remnant of the tree may no longer make a positive contribution to the streetscape.

To plant trees that can develop freely with the minimum number of complaints, you need to weigh up the following considerations:

- The nature of the building facade
- The distance between the trees and the building
- The distance between the trees
- The tree species
- The pruning method

In real terms, this means that when planting new trees, *minimum distances* must be adhered to. Greater distances should be used when planting trees with a broad, dense crown, such as plane and horse chestnut.

Trees may only be planted at shorter distances than given in the table:
- When planting trees with a columnar or thin crown
- Along 'blind' walls
- When special pruning methods are used, such as espalier, pyramid pruning and pollarding
- When only a few trees are planted along a street frontage

Rows of trees let through very different amounts of daylight, depending on whether the crowns of the trees join together (closed) or are spaced apart. This makes it important to note the relevant planting distances for the various size classes.

Planting

As a rule trees are planted between 1 November and 15 April. They are then resting and have the best chance of becoming established.

Standard sizes of trees for planting are:
- 14–16 cm girth (approx. 5 cm diameter)
- 16–18 cm girth (approx. 6 cm diameter)
- 18–20 cm girth (approx. 6.5 cm diameter)

The price ratio for these sizes is 1:1.5:2.

Planting distances for rows of trees:

Size class	open row (spaces between crowns)	closed row (crowns touching)
size class 1	> 18 m	5–10 m
size class 2	> 12 m	5–8 m
size class 3	> 9 m	< 5 m

Minimum distance between the buildings and the centre of the stem[54]

size class	min. distance stem to building
size class 1	6 m
size class 2	4 m
size class 3	3 m

In urban renewal areas where high levels of vandalism are expected it is better to plant fewer larger trees rather than a larger number of thinner trees.

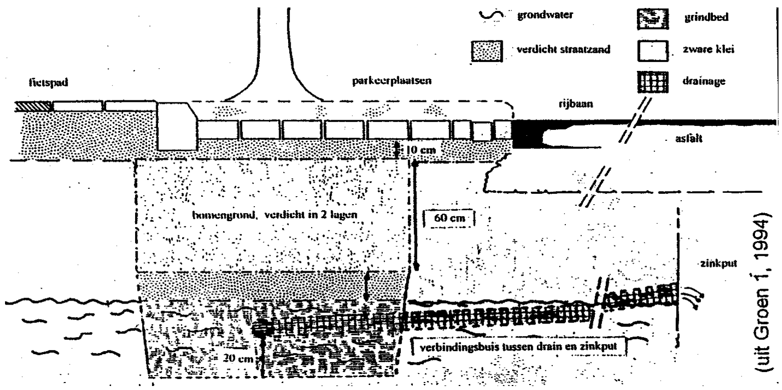
Transplanting

Trees with stems about 30 cm diameter can be transplanted; the larger the tree, the more expensive the operation. Trees with bigger stems can be transplanted, but their chances of survival are much smaller. Ensure that the root ball is as large as possible (min. 3 m across and 1–1.5 m deep). If you know well in advance that a tree will be transplanted the roots can be cut when the tree is still standing, and new hair roots will grow to form a neat compact root ball. This can be done is summer or winter.

The latest method is to soak the root ball in winter. This then freezes to create a solid ball of soil and roots. The tree can then be lifted out with a crane and transported by trailer to its new site. After planting (good pit and tree soil, etc.) the tree should be pruned to restore the balance between the root system and the crown. Prices depend on size, transport options (disconnecting the overhead tram lines, transplanting at night, etc.) and financing. Transporting a Horse Chestnut with a stem diameter of 45 cm over a distance of 1 km (difficult journey, disconnection of tramlines and transport by night) costs about € 10,000 per tree.

groundwater (grondwater)
compacted street sand (verdicht straatzand)
gravelbed (grindbed)
heavy clay (zware klei)
drainage (drainage)

Bicycle path (fietspad)
Parking places. (parkeerplaats)
Tree soil, compacted in two layers (bomengrond verdicht in twee lagen)
Road (rijbaan)
Asphalt (asfalt)
Soakaway (zinkput)
Pipe between drain and soakaway (verbindingsdrain tussen drain en zinkput)



(Source: *Groen* 1, 1994)

Fig. 152 *Modern tree pit design for the trees in the Plantagemiddenlaan, Amsterdam*

1.4.3 Tree planting and the urban space

Visual effects

Different visual effects can be reached applying loose groups and solitaires, rows, rhythm, screens, walls or diferent canopies.[55]

Loose groups and solitaires

The plants are allowed to grow in their natural form and are often used to create a contrast between a 'hard' architectural element and a loosely structured planting scheme. A 'loose' planting scheme can only be used when there is sufficient space available. Solitary trees are, in effect, 'green monuments'; they often stand in special locations and have a striking form (e.g. a Lime tree in the village square).

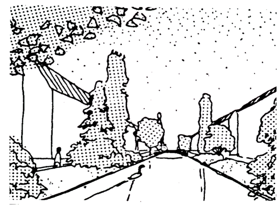


Fig. 153 Loose groups

Rows

A planting scheme in which the distance between trees is so great that the crowns cannot meet. Rows are often used for long, regular street frontages. The free-standing trees provide some visual articulation along the length of the street. In rows the specific characteristics of the tree species are the key visual features: each crown is clearly set off against the buildings.

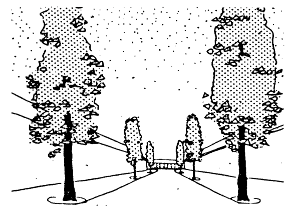


Fig. 154 Rows

Rhythm

Comparable with a row, but in this case the trees are planted in such a way that the visual articulation they provide is integrated into the design structure of the built environment. A rhythm may consist of solitaires. This planting pattern can be a good solution for situations where there is not enough space for continuous planting schemes. Instead, many trees can be planted on corners or other regularly occurring sites where there is more room.

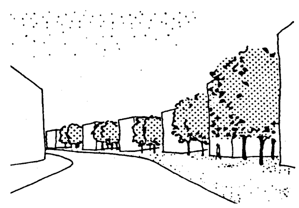


Fig. 155 Rythm

Screen

A screen is a transparent wall of trees through which the facades of the buildings are more or less visible, depending on the viewpoint. A screen is best created using species with an open crown in which the branches do not grow in one main direction so that they easily flow together to form a visual whole. Elms are good trees for creating a screen. Some other species, if planted close together and with some extra pruning, can also be used to create a screen effect. A problem, though, is that if the trees are planted close together the transparent effect can easily be lost.

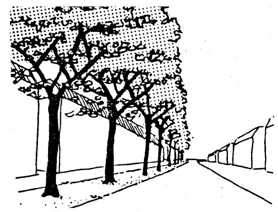


Fig. 156 Screen

Wall

A wall consists of multiple rows of trees planted short distances apart so that the crowns grow into each other. If tree species that develop dense crowns are used (e.g. Lime) it may even be possible to plant just one row; the trees must then be no more than 8 m apart. In the summer this planting scheme creates the effect of a 'green wall'. It is important that the trees form a continuous whole. If the planting distances are too great or if too many trees are missing from the row, the wall effect is largely lost.

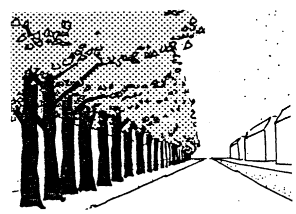


Fig. 157 Wall

Canopy

A canopy consists of multiple rows of trees short distances apart and with intertwining crowns. The most suitable trees species are those with a broad, fairly open crown. The canopy effect is largely lost if the trees are planted too far apart to form a unified mass.

Fig. 158 Canpy

Habitat

The choice of tree species, pruning method and intensity of the maintenance regime are determined partly by the street profile. The biggest problems arise in narrow streets with trees that are too large. In narrow streets with pavements between 3 and 5 metres wide, only trees with a narrow pyramidal or columnar crown should be planted. Trees with a broad pyramidal crown or a definite spreading habit must be planted at least 7 m from the nearest building.

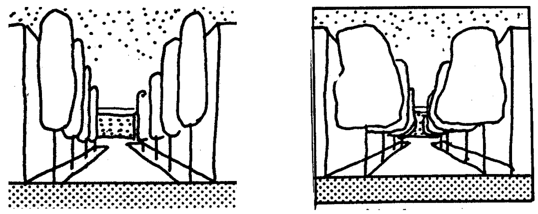


Fig. 159. Columnar or pyramidal crowns in narrow streets

Trees in size classes 2 and 3 are also suitable for planting in these situations. Fig. 160 shows a cross-section through a narrow pyramidal tree in a narrow street. This tree requires a lot of pruning:
Crown thinning: pruning branches back to allow daylight penetration to the buildings
Possibly crown reduction: shortening lateral branches to prevent them touching the buildings
In wider streets with pavements at least 6 m wide it is possible to plant trees that have a more spreading habit. The maintenance work required is comparable with that in example *A*.

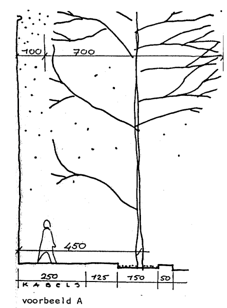


Fig. 160 *Narrow columnar habit*

Fig. 161 shows a tree with a columnar crown has been used. These require less pruning: only crown raising and possibly a little thinning. Unfortunately, few species have this habit. The well-known *Populus nigra* ‘Italia’ cannot be planted in narrow streets because its very shallow roots push up the hard surfacing (heave). This species requires a zone about 5 m across free of hard surfacing.

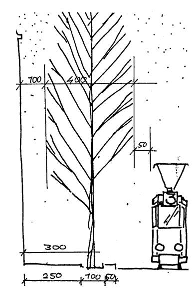


Fig. 161 *Pyramidal habit*

Fig. 162 shows a tree planted near a private garden. In these cases, medium-sized trees should be planted no less than 5 m away from the edge of the garden. For trees with a spreading habit, like Plane and Horse Chestnut, this distance may need to be as much as 15 m. This distance must be adhered to prevent:

- the tree blocking out all light to the garden;
- undue sucker growth in the garden;
- spreading branches.

In special cases, meetings can be held with local residents/users about planting trees in or near private gardens, but firm maintenance agreements will have to be made.

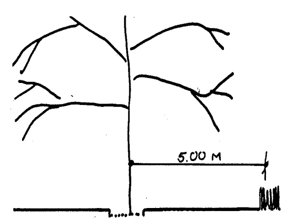


Fig. 162 *Tree close to private garden*

The sensitivity of certain species to climatological influences, particularly when they get older, can pose considerable problems. The most striking example is vulnerability to wind. Large, spreading branches are highly dangerous and may lead to liability problems for the party responsible for maintenance (usually the municipal council).

Achieving the desired visual effect

Besides the habitat of the trees, other essential factors in achieving the desired visual effect are the choice of species and planting scheme. If, for example, a screen of trees is to be planted in a street, the designer will have to decide whether to use a slow-growing species at short distances apart or a fast-growing species planted further apart. In narrow streets, however, fast-growing species will soon cause problems and it is better not to use them.

There are three methods for achieving a reasonably good planting(visual effect(time)) in a relatively short time:

- plant slower growing trees at short intervals;
- plant a mix of fast and slow growing species;
- plant semi-mature trees (more than 10 years old).

Re 1: Planting at short intervals quickly yields a reasonably good visual effect. Short distances between trees are often necessary to obtain a screen or wall effect. An advantage of planting trees close together is that the trees compete for light and quickly grow upwards, giving an upright habit with straight stems. A disadvantage is the extra pruning that is often required.

Re 2: Mixing species with different growth rates requires intensive maintenance work which must be carried out promptly. It is only recommended for planting in broad strips of vegetation (woodland planting). The advantage here is that slow growers are ‘forced up’ by faster growing species. This only works with some species: elms can be combined with poplars; oaks grow too slowly and are eventually shaded out.

Re 3: Another option is to plant semi-mature trees at their final distances apart. Semi-mature trees, however, find it hard to adapt to their new habitat and it takes a few years before they grow at their normal rate again. Moreover, transplanting is an expensive business. An advantage of container trees is that they can be planted easily and successfully at any time, even outside the planting season. This makes these trees highly suitable for use in special situations: rapid restoration of planting schemes in squares or along an important road, or after accidents, etc. However, container trees are often slow to become established and can be ‘overtaken’ by smaller, root-balled trees.

Planting distances

When deciding on the planting distances needed to achieve the desired visual effect the following points should be considered:

- the final diameter of the crown of the tree
- height of the tree
- the habit of the tree (tree shape, height/width ratio, openness of the crown)
- the root system
- shading of nearby buildings
- width of the road and path (for canopy effect)
- the relation between the final height of the tree and nearby buildings
- the period needed to achieve the desired visual effect

A number of examples are presented to explain points 1, 2 and 3.

Road and street planting, seen from the carriageway

Seen from the carriageway, rows, screens, walls and canopies create increasingly enclosed effects.

Visual contact with the wider environment. Trees planted at 20 to 30 m intervals form an open row which permits a good view of the wider environment (trees of size class 1) (See Fig. 163).

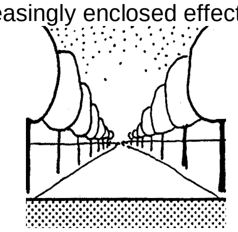


Fig. 163 *Screen/row*

Greater delineation of the road; a wall gives a stronger effect than a screen. Planting intervals should be no greater than 10 m to allow the crowns to grow together. A careful choice of species is necessary because not every species grows well in this configuration (See Fig. 164).

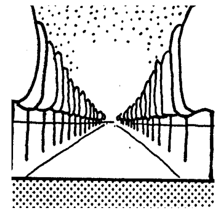


Fig. 164 *Wall*

The vault: the trees have an upright habit (with branches at an angle of 45 to 60 degrees). The crowns just meet to form a very high 'roof'. A narrow road planted with Elms creates this effect well (See Fig. 165).

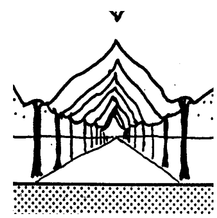


Fig. 165 *Canopy, vault*

The flat canopy: mature broad pyramidal trees or trees with overhanging branches give a flat, broad canopy. The branches grow at an angle of 0 to 45 degrees. Trees that can be used to create this effect are Oak, Horse Chestnut and Lime (See Fig. 166).

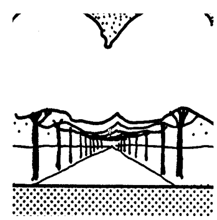


Fig. 166 *Flat canopy*

The cathedral effect: two rows on either side of the road, the crowns of the inner rows are lifted higher than the outer rows(See Fig. 167).

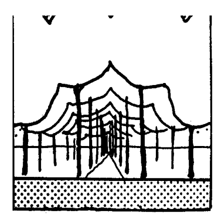


Fig. 167 *rows are lifted higher than the outer rows*

Planting distances

Planting distances have a considerable effect on the urban environment according to the applied size class.[56]

Closed screen or wall

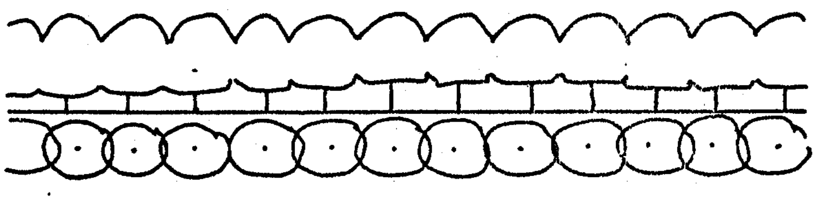


Fig. 168 *Trees of size class 1; planting distance 5–12 m; open under the crowns*

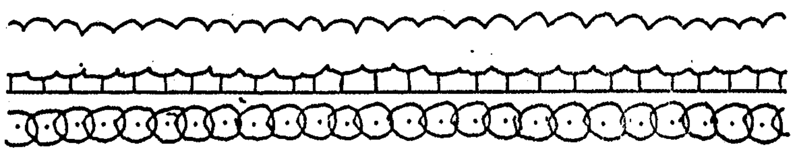


Fig. 169 *Trees of size class 2; planting distance 3–8 m*

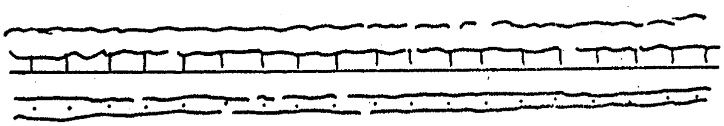


Fig. 170 *Trees of size class 3; planting distance 2–4 m*

Row

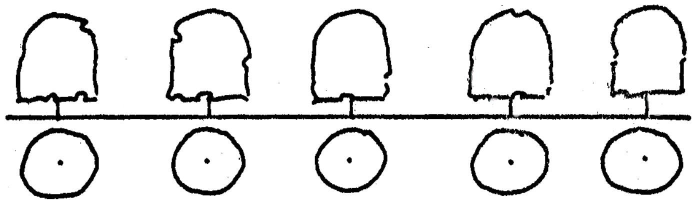


Fig. 171 *Trees of size class 1; planting distance 20–30 m*

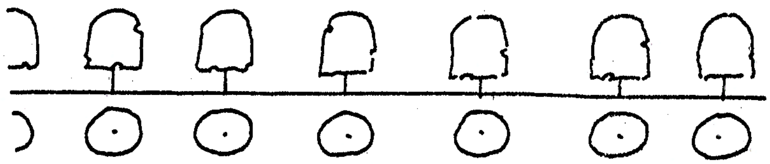


Fig. 172 *Trees of size class 2; planting distance 15–30 m*

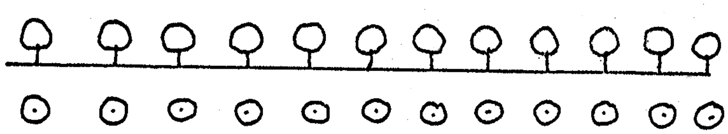


Fig. 173 *Trees of size class 3; planting distance 10–20 m*

Silhouettes of the different trees

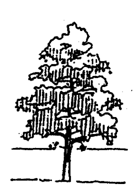


Fig. 174 *Alder (els)*

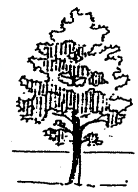


Fig. 175 *Black Poplar (populier)*

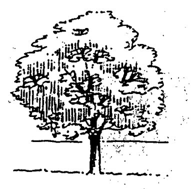


Fig. 176 *Ash (es)*

Fig. 177 *London Plane (plataan)*

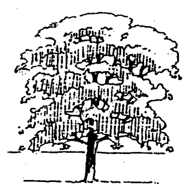


Fig. 178 *Elm (iep)*

Fig. 179 *Common Oak / Pedunculate Oak (eik)*

Fig. 180 *Downy/White Birch (witte berk)*

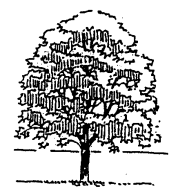


Fig. 181 *Sycamore / Great Maple (esdoorn)*

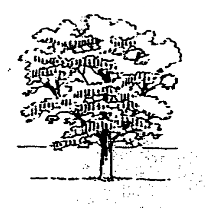


Fig. 182 *Locust Tree / False Acacia (acacia)*

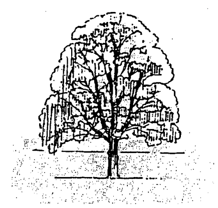


Fig. 183 *Common Lime (linde)*

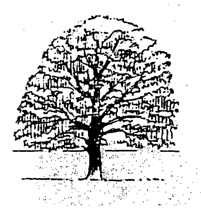


Fig. 184 *Common Beech (beuk)*

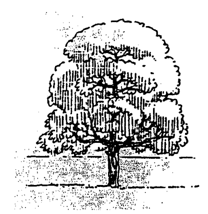


Fig. 185 *Horse Chestnut (kastanje)*

Fig. 186 *Weeping Willow (treurwilg)*

Fig. 187 *White Willow (schietwilg)*

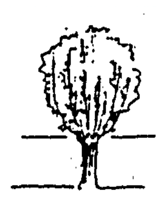


Fig. 188 *Pollarded Willow (knotwilg)*

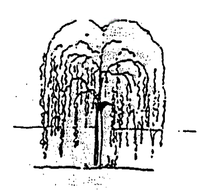


Fig. 189 *Weeping Ash (treures)*

Pruning

There is a balance between the amount of leaves and roots a tree has. If too much growth (above ground) is cut away the tree will compensate for its shortage of leaves by throwing up many new shoots. Pollarded trees such as Poplar and Willow must be pruned each year. Trained trees/espaliers are grown for their architectural form. Examples are:

- Lime
- Plane
- Hornbeam

A nursery grown tree has been pruned in the nursery to obtain a clear stem height of 2 m while its natural form is maintined. During the first 5 to 10 years the crown of the tree will require some light pruning. Trees close to the edges of a road must have their lower branches remove to ensure sufficient clearance for passing traffic.

Trees do not last forever, so do not hesitate to remove old specimens with a limited life expectancy and plant younger trees!

Crown raising

Trees planted along roads and paths should have their lower branches removed. This crown raising (to a height of about 2.5 m) is started when the trees are still young. Depending on the situation, a street tree will have to undergo further crown raising over the years. In some cases up to as much as 7 m above ground level (species with hanging branches).

When raising a tree crown thought should be given to obtaining the right balance between the length of the stem and the crown (2:3 or 1:2). It is an unattractive sight for a tree of 14 m to have a clear stem height of 7 m. In these cases it is better to go for an asymmetrical crown. In the example above the tree may have its crown raised to 4 m on the pavement side, but up to 7 m. on the side above the road. This gives the streetscape a much better appearance. The rows of elms planted along canals are a good example of asymmetrical crown raising. In some cases, pruning will still be necessary on the side facing the buildings to ensure sufficient daylight penetration.

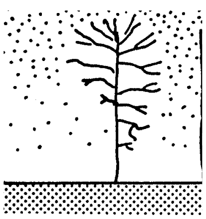


Fig. 190 *crown raising near building*

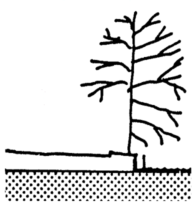


Fig. 191 *crown raising along a canal*

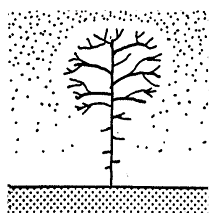


Fig. 192 *partial crown lifting*

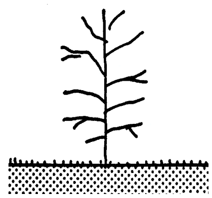


Fig. 193 *crown raising in grass*

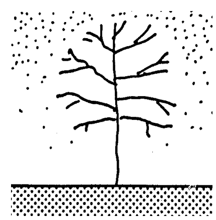


Fig. 194 *crown raising in a street*

Crown raising heights

planting stock	2.5 m
residential streets	3 m
main roads	4.5 m
tram lanes	4.5 m
trees with hanging branches	to 7 m
asymmetrical: housing side	2.5 m
asymmetrical: canal + quayside	2.5 m
asymmetrical: canal + grass	0–2.5 m
in grass	0–2.5 m
in ground cover	0–2.5 m
in low shrubs (to 1.5 m)	0–2.5 m
in medium-sized shrubs (to 2 m)	2.5 m
in tall shrubs (from 2 m)	2–7 m

Summary

The choice of plants depends on:
1. The site and growing conditions
2. Growth characteristics and habit of the planting material
3. The appearance of the planting and the atmosphere it creates
4. Practical aspects (function and goal)
5. Cost and available funds

1. Site and growing conditions
- natural landscape
- cultivated landscape
- urban area
- nature and character of the buildings (tall buildings create windy conditions)

Growing conditions

Soil type
- Sand nutrient rich
- Peat nutrient poor
- Clay
  - o calcareous / lime rich
  - o non-calcareous / base poor
  - o acid
  - o good/poor structure
  - o humus content

Groundwater levels
- high – wet
- low – dry
- water retaining capacity of the soil

Climatological conditions
- sheltered
- exposed
- coastal
- urban area
- industrial site
- wind
- frost

Light requirement
- open site / full sun
- semi-shade
- full shade

2. Growth characteristics and habit

Tree dimensions
- Size class 1
- Size class 2
- Size class 3

Shrub dimensions
- Evergreen – taller than 4 m
- Deciduous 2–4 m
- 0.5–2 m
- less than 0.5 m

Crown shape and habit of trees
- spherical
- spreading
- broad pyramidal
- narrow pyramidal
- columnar
- weeping

Crown shape and habit of shrubs
- groundcover
- spreading
- upright
- compact
- overhanging

Texture
- leaf shape
- leaf size
  - o large
  - o medium
  - o small
- leaf arrangement

Leaf colour
- light green – dark blue-green
- light to dark brown
- yellow
- variegated

Blossom
- flower colour
- flowering season early spring
- spring
- summer
- autumn
- fruit
- autumn colour
- bark

3. Appearance

Visual effect
- ankle height
- knee height
- waist height
- breast height
- eye level
- above eye level

Mutual relation between elements
- harmony
- contrast
- rhythm
- decorative value

4. Practical aspects
- winter hardness
- vitality
- disease resistance
- abundant and/or long-lasting blossom
- function in the plan
- spatial layout
- relation to buildings
- relation to existing planting
- client's wishes
- wind protection
- shade
- traffic guidance
- noise reduction
- enclosure
- ground cover

5. Costs
- purchase costs and required dimensions
- intensity of maintenance
- length of implementation period
- available financial resources

1.4.4 Hedges

Hedges divide the space where a fence or wall is undesirable. The primary function of a hedge is always separation, most obviously to divide two uses, for example to divide a private space (garden) from the public space. Hedges provide a natural background for other plants; thorny hedges form an impenetrable barrier. Hedges have an important spatial effect. They can be classified into those which divide up the space in which they stand ('free-standing') and those that form part of a larger mass immediately behind them.[57]

When the spatial impacts of hedges are examined more closely, it seems obvious to classify them by height. According to their application, we can then distinguish: edges (to approx 0.5 m high), partitions (0.5–1.5 m) and full screens (more than 2 m high). Their respective applications are: as an edge when used to mark out patterns or a composition of lines, as partitions when their function is to resist or direct movement, and as a full screen to visually seal off a space.

One spatial effect of hedges is to facilitate comprehension of the scale of the space and the elements in it, because the hedge has a consistent size (height) which serves as a reference on a human scale. Another spatial effect is created if the hedge is quite long and forms a connecting element that provides continuity. For this purpose hedges do not have to be trimmed; a row of shrubs (a 'loose hedge') can also create this effect. Besides their spatial effects, hedges may also, possess a number of intrinsic characteristics.

Natural (loose) habits of shrubs can be tightened up by pruning to form a hedge. These neater forms give hedges a more cultivated appearance, and the hedge is a symbol of continuous human intervention in the natural process of growth. A trimmed hedge can be used in two ways:
As a contrast with 'looser' forms in the surrounding area, or with a less cultivated environment (e.g. a neat hedge around a farm, set in an agricultural or quasi-natural landscape).
As a harmonising element; the regular 'architectural' shape of the hedge harmonises with an architectural, usually urban, environment.

Hedges may have an *ornamental value*, which cannot be seen in isolation from the above – the contribution the hedge makes to the appearance of the wider environment. The characteristics of hedges discussed above make them an ideal means to accentuate a prominent location.

Hedges have two major disadvantages. First, they have to be pruned regularly, in some cases two or three times a year. Second, they take up considerable quantities of nutrients, which are then not available for any plants near the hedge, making regular fertilisation necessary.

Hedges for marking out spaces

Hedges between the main road and bicycle lane or footpath

These hedges are planted for traffic safety reasons: they make crossing impossible and at night they prevent glare from the headlights of oncoming traffic. These street profiles are only found in post-war urban areas and non-urban areas. Trimmed hedges require a lot of maintenance, though, and in these situations can easily be replaced by untrimmed hedge/shrub planting if there is sufficient space, or, in places where the safety function is not essential, by a normal verge.

Hedges along watercourses

(See Fig. 195)These are also planted for safety reasons, to keep children away from the water. *The hedge is a friendlier type of fence*. The need for and value of hedges in the neighbourhood should be determined. Such hedges do not remove the danger altogether, but keep it at a distance and make it less threatening, but, because of this very effect, can make the (unknown) danger much greater.

In addition to the functions mentioned above, these uses of hedges can enhance appreciation of the scale of the space in which they stand.

Hedges as a visual screen to hide (mainly) parked cars

(See Fig. 198)This use of hedges is particularly dependent on the environment. They are suitable for this purpose in an urban environment, but in other environments they can easily be replaced by an untrimmed hedge or shrubs. It may even be worth considering removing some taller plants; owners often want to see their parked cars from the house.

Hedges as space-shaping elements

Hedges can create their own separate (sub)rhythm different in character from the larger space they are part of. An example is a garden surrounded by a hedge, possibly in a park, the regular form providing a contrast that sets off the space. In this case the trimmed hedge is an essential element. Should the situation within the hedges ‘not work’, it is better first to see if another use of the space can improve the situation before deciding to grub up any hedges. Hedges are planted around playgrounds and seating areas mainly for safety reasons because they stop children running onto the road. Besides this strictly functional aspect, hedges also provide ‘shelter’ and ‘security’ for the play area. In other words, the hedge marks out a territory.

The same quality of ‘security’ or ‘cover’ is provided by hedges surrounding a sitting area with benches. A trimmed edge is justified around such areas if they form a contrast with the loose forms in the area and so create their own place, or if the site is located within a paved area where the use of hedges adds an architectural dimension and has a practical effect of saving space (the ‘paved character’ relates to walls as well as horizontal surfaces).

Hedges as edging for a mass

The hedge as linear element

A tall or medium-sized hedge can provide a background for roses, for example, or a border. Removing such a hedge often destroys the appearance of the border and is only advisable if the border is of a sufficient size.

Hedges that form a pattern or composition of lines

Very low hedges, which are essentially an edging, are found around borders of roses or perennials. Often they are laid to give the border a less dreary look when there is little to see in the border itself. This situation has value only if two conditions are met:

The height of the hedge is in proportion with the planting material in the border
The hedges themselves form a particular pattern that is interesting enough when the roses of perennials have been pruned or cut down.

Use of these types of hedge is only justified in prominent places or in situations where there is very little green. Moreover, their maintenance is time-consuming in proportion to their length. Sometimes a compromise solution is acceptable to reduce the length of such hedges.

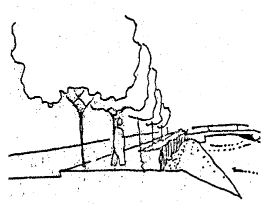


Fig. 195 *Hedge along watercourse*

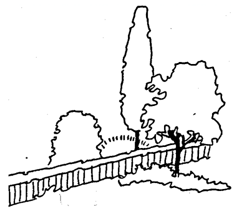


Fig. 196 *Contrast*

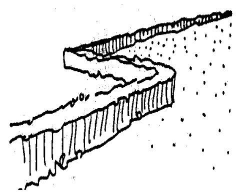


Fig. 197 *Hedge in open space*

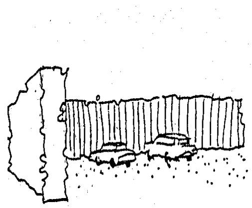


Fig. 198 *Hedge bordering car park*

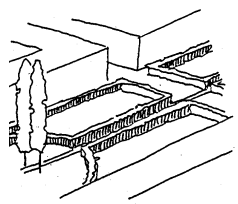


Fig. 199 *Harmony*

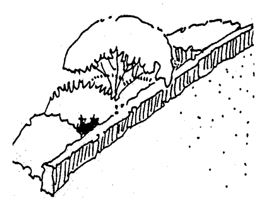


Fig. 200 *Hedge as part of a mass*

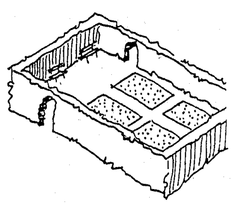


Fig. 201 *Hedge enclosing a garden*

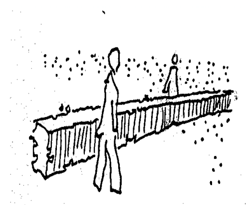


Fig. 202 *Partition*

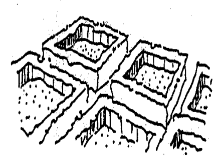


Fig. 203 *Edges*

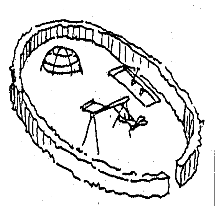


Fig. 204 *Hedge round a 'place'*

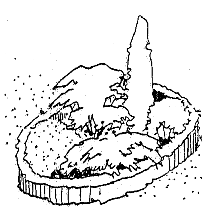


Fig. 205 *Hedge bordering shrub bed*

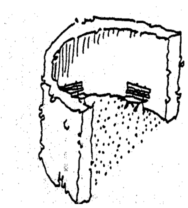


Fig. 206 *Complete screen*

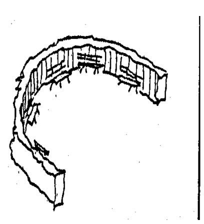


Fig. 207 *Shelter for seating*

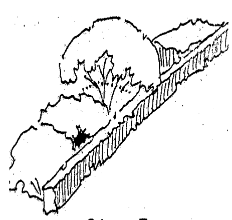


Fig. 208 *Edge*

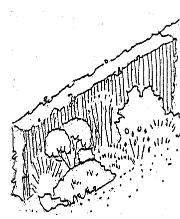


Fig. 209 *Background to border*

	Planting distance	Loose/regular	Growth rate
Evergreen hedges			
box (*buxus sempervirens*)	$5/m^1$	regular	
holly (*ilex aquifolium*)	3 à $4/m^1$	regular	
common yew (*taxus baccata*)	$3/m^1$	regular	
holly (*ilex aquifolium*)		loose	
privet (*ligustrum ovalifolium*)	3 à $4/m^1$	regular	
size 40–60			
deciduous hedges			
hornbeam (*carpinus betulus*)	$4/m^1$	regular	
beech (*fagus silvatica*)	3 à $4/m^1$	regular	
hawthorn (*crategus monogyna*)		loose	
blackthorn (*prunus spinose*)		loose	
rose – botanical roses		loose	

Growth rate: number of years until the plant reaches a height of 1.5 metres (depending on habitat, soil type and maintenance)

Pruning hedges

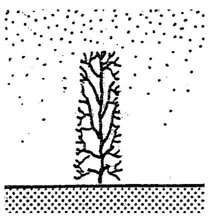


Fig. 210 *vertical*

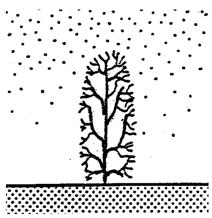


Fig. 211 *rounded*

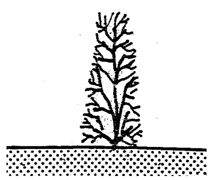


Fig. 212 *tapered*