Flower richness green veining

Monitoring flower richness using remote sensing & artificial intelligence

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What is green veining?

Green veining consists of natural linear elements in the landscape. Think of alder girths, hedgerows, hedges and hedges, avenues, thickets, quays and dikes, garden walls, flowery (plot) edges and verges.

The green veins is an important habitat for many plants and animals and functions as a corridor for different ecosystems.

Dikes are a valuable part of the green veining system in the Netherlands. Many plant species are found on flower rich dikes, such as the little pimpernel, the harebell, wild carrot, parsnip, yarrow and yellow morning star. The many continuous kilometers of flower-filled dikes form a network with a high biodiversity. The dikes are important habitats for many species, where they find food and nesting places. In addition, the linear dikes are used by many species as a connection between other, large habitats. Flower rich dikes are also important for the safety of dikes; they are more resistant to erosion due to the structure of the rooting. (see project 'Future Dikes').

> Dikes are a valuable part of the green veining system in the Netherlands.

Examples of flower rich and flower poor dikes and flowers that can be found there.

Monitoring of flower richness

Our current landscape offers little habitat for wild plants and animals. Biodiversity in agricultural and urban areas is low and the number of species and numbers in which they occur are still declining.

To reverse this negative trend, more and more measures are being taken to manage and design the green veining in a more ecological way. As a result, dikes, verges and hedgerows become more natural and diverse and offer space for more flowering plants. The flower rich vegetation provides food and shelter for insects, birds and mammals, for example.

These control measures are increasingly being taken at regional level, with different organizations working together on a more biodiverse landscape. Examples of this are the Groene Cirkel Bijenlandschap en Bijenlandschap West-Brabant.

It is important for the collaborating parties to have a good overview of the flower richness of the network of green veins: Which parts are flower rich and where improvements still need to be made? By periodically charting the abundance of flowers, you can monitor the quality of the network of the green veins and make better adjustments to management.

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> Flower rich dikes provide plenty of food and nesting opportunities and act as a corridor and are therefore of great importance for biodiversity.

Improve monitoring

Collecting data in the field is very labor intensive. Deriving the richness of flowers from the management maps of governments and organizations is also very laborious and indirect. That is why we looked for a method to be able to map the flower richness in a standardized and simpler way.

Remote Sensing (RS) images, such as aerial photos and satellite images, are increasingly available (publicly) and are of increasingly better quality (higher resolution). Also the methods of automatic image recognition by means of artificial intelligence (AI) is getting better and better.

In this project we looked at whether it is possible to recognize the flower richness of green veins using RS images and artificial intelligence. To explore this, we looked at whether we can recognize the abundance of flowers on dikes for a number of dikes in Gelderland and Utrecht.

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Study area

As a study area we have chosen the Betuwe river area along the Neder-Rijn between Wijk bij Duurstede and Amerongen (the Rijndijk-Lekdijk), between Maurik and Kesteren (Rijnbanddijk) and along the Waal near Andelst between Dodewaard and the A50 (the Waalbandijk -Waaldijk).

Reasons why this area was selected:

- The availability of (high-resolution) aerial photos at the moment (May 31 and June 1, 2021) when many flowers are in bloom and not yet mowed.
- The availability of good (cloud-free) satellite images (SuperView) at almost the same moments (28 May and 1 June 2021).
- The presence of many flower rich dike sections (mainly outside the dikes). Many of the river dikes in this area of the Neder-Rijn and Waal have been sown with flower/herb-rich mixtures after the dike elevations and they are locations (including the Rivierenland water board and the De Stichtse Rijnlanden water board) where trials are being conducted with the (mowing) management of flower rich dikes.

Map of the study area

Below you can see the study area in more detail (aerial photo from May/June 2021) with photos of the field visit from 2022 in the same period. This shows that there is a good agreement between the flower richness in the field and that in the aerial photo, even after one year. Only areas that have been mowed deviate.

Flower poor dike

Flower rich dike

Flower richness on dike

Flower rich dike

Flower rich dike

Mown dike

Mown dike

Flower rich dike

Flower rich dike

Flower rich dike

Flower poor dike

Flower rich dike

Flower rich dike

Flower rich dike

Mown dike

Flower poor dike

Flower rich dike

Flower rich dike

Flower rich dike

Flower rich dike


Flower poor dike


Flower rich dike

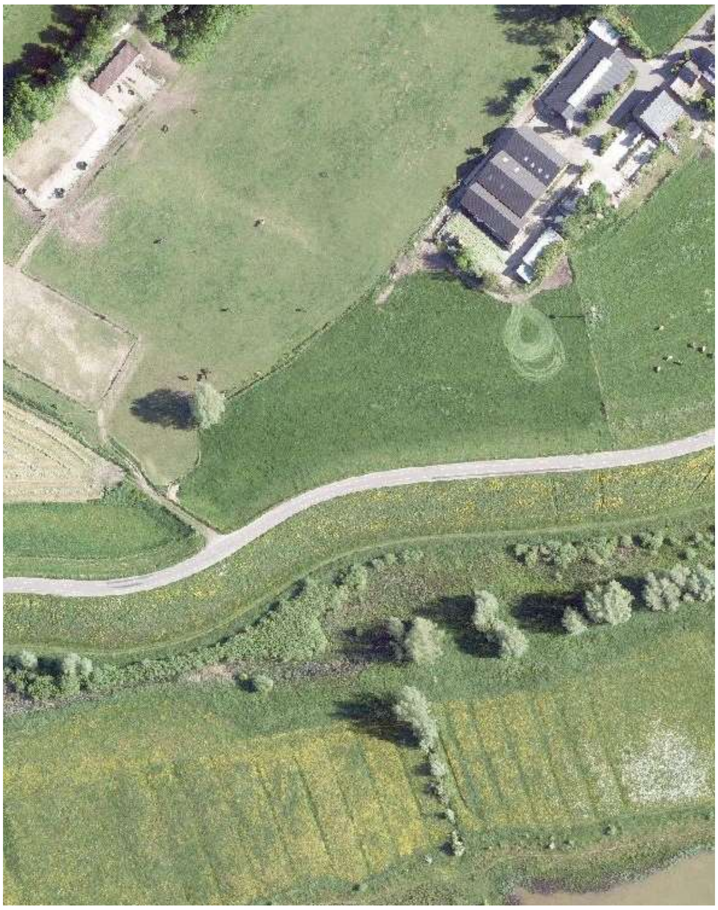

Flower rich dike


Flower rich dike

Remote sensing images

In this study we used the aerial photo from 2021 and SuperView satellite images from 2021. The aerial photos were taken in the period February 18 to June 11, 2021. The 1x1km tiles near Waalwijk are from May 31, 2021 and near Amerongen and Opheusden from June 1, 2021. These images clearly show that flowers are in bloom. SuperView images are also available for almost the same dates, namely May 28 and June 1 (see appendix for additional information). Having both remote sensing images in the same period gave us the opportunity to interpret the satellite images on the basis of the aerial photos.

The two figures below show the difference between the aerial photo (01-06-2021) and the SuperView image (01-06-2021). The aerial photo shows much more detail, but less often a shot is available than the SuperView images.




Differences between the aerial photo and the satellite data are visible in the swipe map on the right.

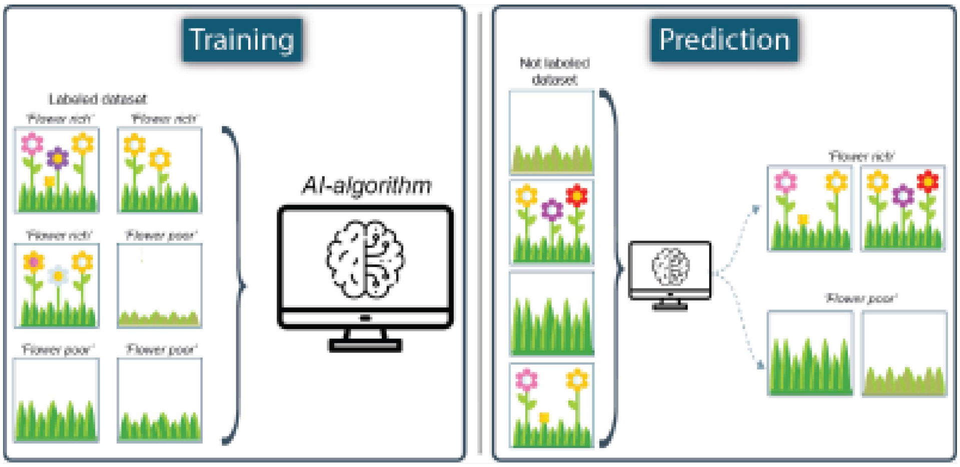
(move your mouse in the middle of the map on the blue button and drag your mouse left or right to see the differences)

Another example can be seen below. It is easy to see that flower rich dikes are more visible on the aerial photo, but you can also see the yellow glow of the flowers on the satellite image.

Use of AI model

An artificial intelligence (AI) model* was used to recognize flower rich dike elements. Before the model can distinguish flower rich from flower poor, it must be trained. Based on both the aerial photos and the SuperView images, 800 dike samples (plots) were collected of 10x10m. Both sets consist of 400 flower rich and 400 flower poor plots.

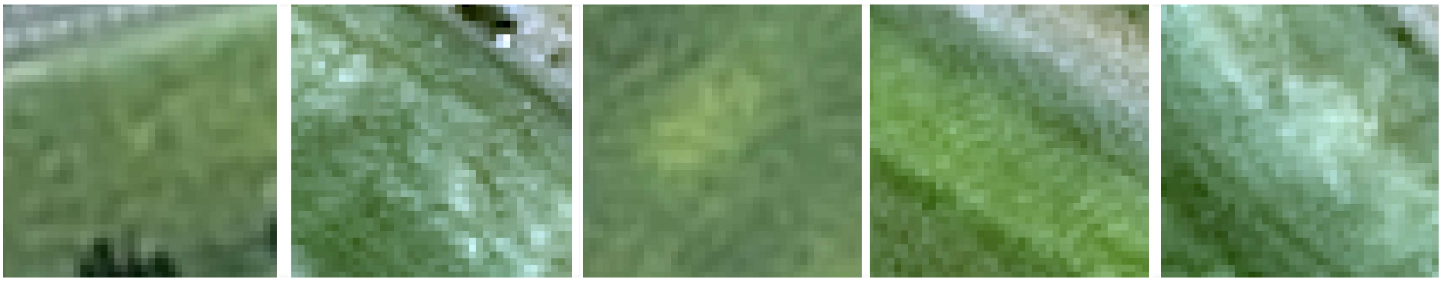
* In this study, we used the AI model known as EfficientNetB0. This model is especially intended for image classification applications.



Visualization how the AI model is made.

Flower rich dike samples based on the aerial and satellite image

Aerial photo



Satellite image

Flower poor dike samples based on the aerial and satellite image

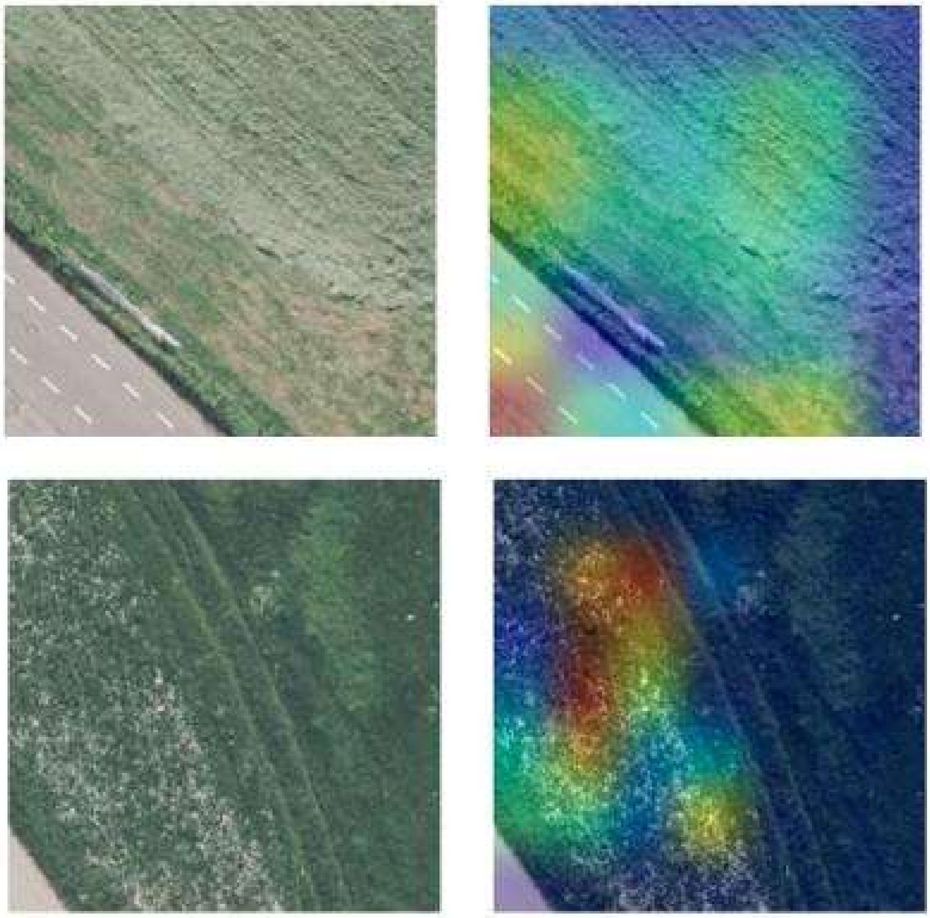
Aerial photo

Satellite image

The selection of dike samples was done manually on the basis of the aerial photo from 2021. In 2022, these were checked by means of a field visit. This showed that after one year the flower richness corresponded well with the situation that could be seen on the aerial photo. In addition to flower rich or flower poor vegetation, many plots also contain parts of roads, fences, trees and shadows.

Using image processing software, the set was enlarged (including random rotation/zoom/contrast operations) to have sufficient training data. Ultimately, 70% of both datasets (aerial image and SuperView image) were used for model training and the remaining 30% for validation and testing.

The figures below show a number of so-called 'class activation maps' for a number of dike samples. These figures provide insight into what exactly the AI model looks at in the 10x10m image (mainly the red areas) and ultimately determines whether it concerns a flower poor or flower rich plot.



Class activation maps.

Results

Based on the aerial photo, the AI model was found to be very accurate in distinguishing flower rich and flower poor dike samples.

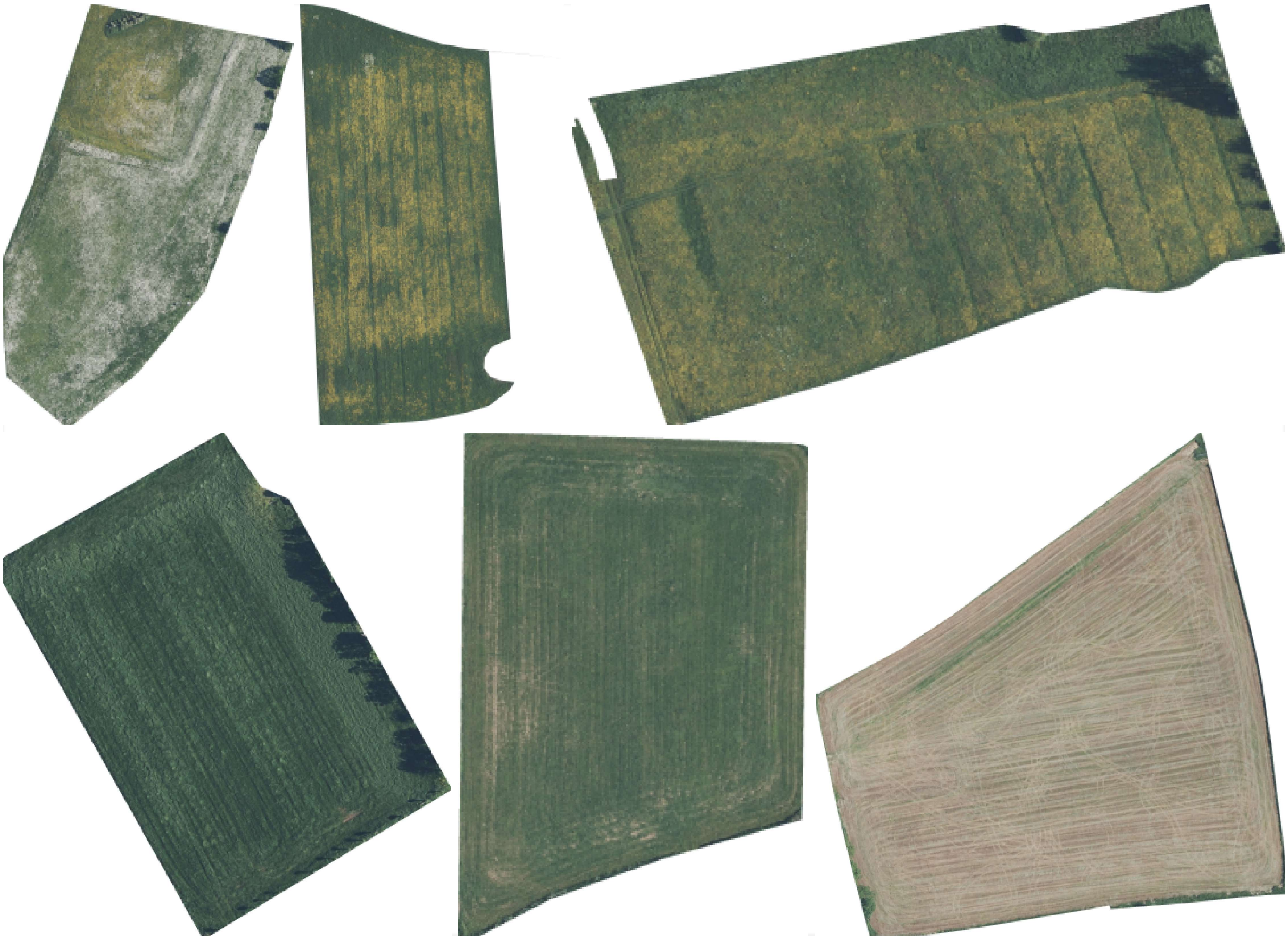
The resolution of the aerial photo is so good that the trained model got 99% of the validation set right.

In the case of the SuperView images, the model was slightly less accurate than in the aerial image, but still high with an accuracy of 83%. The lower accuracy is due to the limited resolution of the satellite images (50cm). It is sometimes difficult to see with the naked eye whether it is flower rich or flower poor. A trained model can therefore make a better distinction than is visually possible.

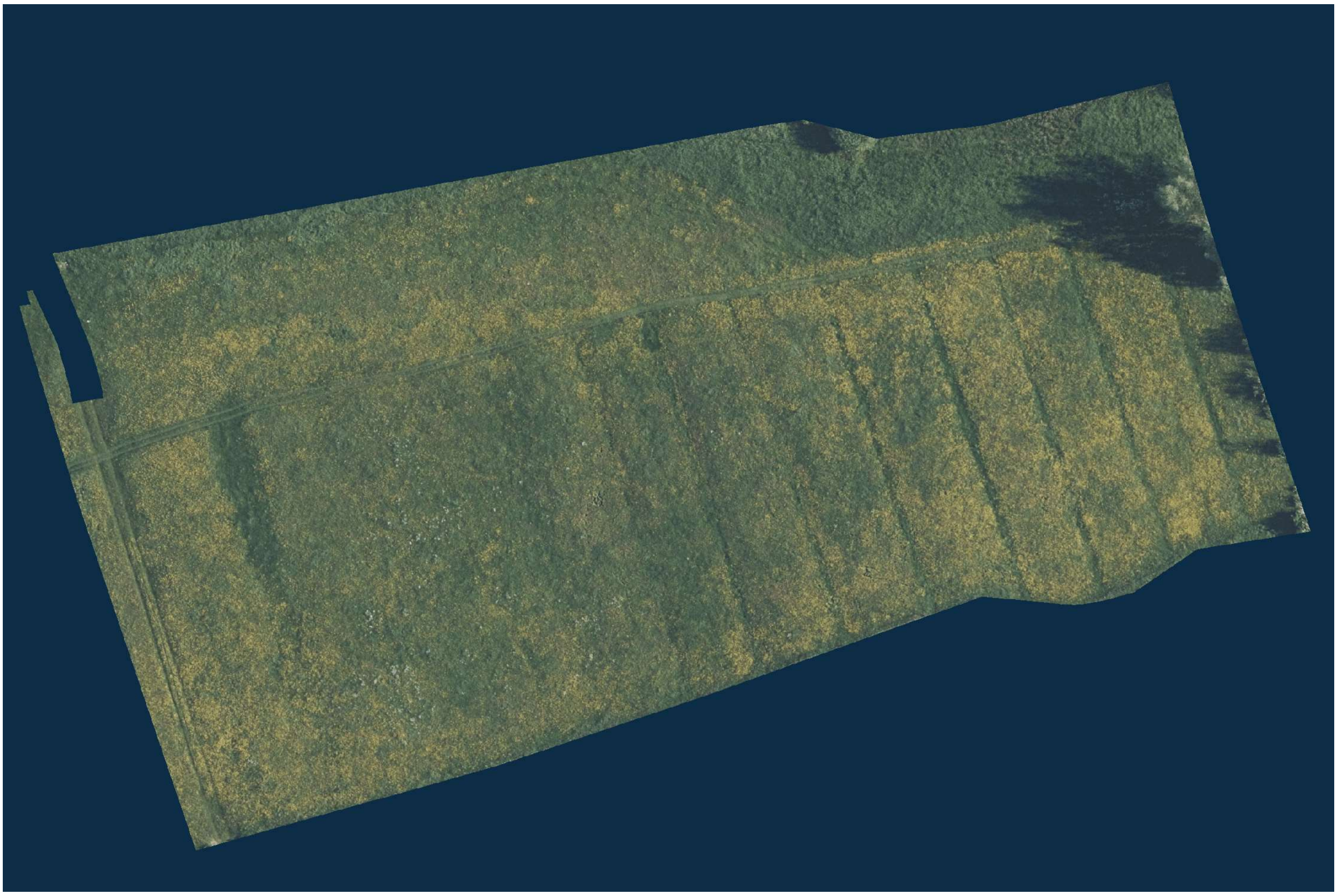
The results show that based on both aerial photos and satellite images (with sufficient resolution) and AI techniques, it is possible to distinguish flower rich and flower poor dikes (samples).

Grassland parcels

In the context of biodiversity, herbaceous grassland plots are of great importance. To see if the AI model can also be used for recognizing herbaceous/flower rich grassland plots, we tested the model for a small set of grassland plots (50, of which 25 flower rich and 25 flower poor), based on just the aerial view.



Example of a few grassland parcels.



The AI model turned out to be quite capable of recognizing flower-rich and flower-poor plots. The overall accuracy of the model is 99%.

Because the grassland plots are too large for the AI model, each plot is cut up into small pieces, after which each piece is classified separately (flower rich or flower poor).

In a number of cases the model had trouble with very flowery pieces. Due to the homogeneity of the flowers over the entire photo, it was classified as flower poor.

The presence of cows can also influence the model. In this case, the image was classified as flower richness.

Conclusions

This research shows that the floral abundance of dike elements, as part of the green veining in the Netherlands, can be mapped using aerial photos or high-resolution satellite images in combination with AI techniques. In addition, this method can also be successfully applied to grassland plots.

An important precondition for the successful application of this method is that good recordings (RS images) are available. That is, the images:

- be cloud-free as much as possible;
- have sufficient resolution in relation to the size/width of the green veining landscape elements (see some examples below);
- and have been recorded at the right time, namely the moment

when:

- That the flowers/herbs are in bloom
- Not mowed yet.

Limits:

Recognition of flowers at species level

In this study we have limited ourselves to the question of whether an element is flower rich or flower poor. A next step could be to recognize flowering plant species, but the remote sensing images used are much too coarse for that, even the 8cm aerial photo.

Narrow landscape elements

Not every linear landscape element can be monitored using aerial photographs and/or high-resolution satellite images. Based on the RS images used, relatively large elements such as dikes, plots, and verges along highways and grassland plots can be used to monitor the flower abundance with this method. These are generally wide enough so that images with sufficient resolution can be used.

Some examples:

- Dikes (our study area)

Click here to zoom to a dike

- Grassland plots (our study area, Friesland) and field rounds (sufficiently wide).

Click here to zoom to a parcel

- Verges along highways. Verges along provincial roads and in the city are often too narrow. In addition, obstacles such as trees, signs and transitions limit a clear view from above. Finally, these verges are intensively managed, which means that the chance of good recordings is even smaller.

Click here to zoom to a highway verge

Availability of good images

The main limitation of this methodology is the availability of usable high resolution remote sensing images.

The inventory of the available aerial photos (from ESRI with images from 2006 to 2020, see Luchtfototijdreis) shows that the usability of these images differs per year and also per location. Sometimes the shots are taken too early in the year and herbs are not yet in bloom. Images may also have been taken too late, when many dikes have already been mowed. For our research, only the spring (or winter) image of 2021 turned out to be partly useful, partly due to the fact that it contains images made before June 11. The availability of images during this period was exceptional, as images are normally taken for the date of April 23 (the 'leafless season'). In addition to the spring/winter image, a summer image is also recorded, usually collected between 15 May and 15 July. However, this period often coincides with the period in which many verges have already been mowed (although more and more people are switching to ecological verge management).

The inventory of the SuperView images from the national satellite data portal has also shown that many images are not usable, despite the aim of 5 to 6 nationwide images per year. However, many of the images are too early in the spring, or too late for the mowing date.

However, it is expected that more and more detailed remote sensing will become available in the future, and that the availability of usable remote sensing images will become less and less restrictive.

Possibilities for follow-up research

• Extension to other elements of green veining
In this project we have shown that we can reasonably recognize the abundance of flowers at dikes using high-resolution remote sensing images. A next step could be to extend this research to other green veining, such as roadsides, embankments or agricultural grasslands. This is of interest to local and regional authorities, nature organisations, farmers' organizations that contribute to biodiversity and want to evaluate their efforts on a landscape scale, e.g. learn or pay.

• Detect development stages of flower richness of grassland vegetation
It can be examined whether a finer distinction can be made in the flower richness and even in the so-called “developmental stage” of the vegetation that is distinguished in this typology by using available high-quality satellite images in combination with machine learning. Use can be made of the typology of vegetation development phases developed in the Future dikes project, which includes characteristics of both the biodiversity and the safety qualities of the vegetation.

Appendix

Aerial photos:
Visual material is a collaboration of Dutch governments with the aim of jointly collecting aerial photos (image material). The spring aerial photos are mainly taken in the "leafless" season (until the end of April), in which the Netherlands is divided into blocks. The various shots (tiles of 1x1km) together form a nationwide photo (mosaic) of the Netherlands. As of 2021, the spatial resolution of this image is 8cm (previously 25cm). In addition, photographs are also taken in spring/summer (collected between 15 May and 5 July). The resolution of this nationwide photo is 25cm.

Satellite images:
The high-resolution satellite images come from the Satellietdataportaal.nl. With this Satellite Data Portal, the Netherlands Space Office (NSO) gives companies, individuals and institutions in the Netherlands free access to high-resolution satellite images (both optical and radar-based images). In this study we used the available SuperView images with a spatial resolution of 50cm (pan-sharpened*). The NSD contains approximately 6 nationwide recordings per year. These recordings also consist of several tiles that are recorded in a certain period (March 1-April 15; April 16-May 31; June 1-July 15; July 16-August 31; September-October 31).

* Pan-sharpened: The spatial resolution of the three color bands (red, green and blue) are adjusted using the panchromatic 50cm black image recording refined to 50cm.

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