



**GRASSIFICATION**

**Interreg**



EUROPEAN UNION

**2 Seas Mers Zeeën**

European Regional Development Fund

# **Grassification**

**D1.1.2**

**Report: Testing & comparison of performance new type of mowing head against existing mowing heads**

## Document Control Page

<b>Title</b>	D1.1.2 Report: Testing & comparison of performance new type of mowing head against existing mowing heads		
<b>Editor</b>	Tom Anthonis, Pro Natura		
<b>Contributors</b>	Nathalie Devriendt, Innec Dominique Cammaert, Delphy Cor van Oers, Delphy Marcella Souza, UGent		
<b>Nature</b>	Document		
<b>Dissemination Level</b>	Public		
<b>Version number</b>	1.0		
<b>Planned Delivery Date</b>	1 11 2019		
<b>Version date</b>	16 12 2019		
<b>Abstract</b>	LP, PP3, PP12 & OP5		
<b>Version</b>	<b>Date</b>	<b>Modified by</b>	<b>Comments</b>
0.1	01.10.2019	Pro Natura	First version
0.2	1.11.2019	Pro Natura	Version with additional information of WP 1 partners
1.0	16.12.2019	Pro Natura	Final version

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## General outline for the testing and comparison of the mowing head

An important goal within the Grassification project is to use roadside cuttings as feedstock for material and energy. The quality of the roadside cuttings is therefore of importance. To serve that goal the Grassification project started the development of a new type mowing head. The new mowing head will be compared to existing solutions on the market and the quality of the grass cuttings to be useful as material and/or energy application.

Pro Natura is responsible for the tests and comparison of such a new type mowing head.

This step is one of the steps towards the realisation to source and process qualitative feedstock material:

D1.1.1: Prototype development of new type of mowing head

Partner responsible: **Pro Natura**

Other partners involved: Innec, Van Daele (observer)

Deliverable date: 1/7/2019

D1.1.2: Testing and comparison mowing head

Partner responsible: **Pro Natura**

Other partners involved: Innec, Van Daele (observer)

Deliverable date: 1/11/2019

D1.1.3: Demonstrating mowing head

Partner responsible: **Pro Natura**

Other partners involved: Innec, Inagro, Kent Wildlife, Delphy +observers

Deliverable date: 30/11/2020

## Context

The tests and comparison of the new type mowing head is situated in WP 1 of the Grassification project. This work package aims at optimising the process from mowing roadside grass to separation in solid and liquid fraction. Through the development and demonstrations of innovative approaches, best practices are developed and disseminated.

The demonstrations on the "cut-and-collect" phase aims at producing the best possible quality of input (minimising dirt content, specific ensilage techniques, etc.).

The novel mowing head will be tested and validated in an operational relevant setting for the target audience and proven market readiness. The support development new type mowing head will aim at minimising dirt content via a co-creation strategy. The performance of the new mowing head will be compared to comparable available machinery.

Within the Grassification project, a set of quality criteria for alternate uses of grass biomass will be discussed and will be provided to equipment developers & field-test equipment as developed by machine builders to serve the needs of biomass refinery processes.

The tests, pilots, demonstration actions and feasibility studies will all be documented in a report. The report will describe the tests and comparison of the performance of a new type of mowing head against existing experiences. The results will support the implementation for a more circular economy.

## Objective of the experiment

The objective of the test was to test two mowing heads (machines):

1. Flail mowing head: constructor Vandaele
2. Circular mowing head: constructor Herder

## Methodology

### Selection of the parameters for comparison

The selection of the relevant parameters was discussed with the partners during the partner meeting on the 20<sup>th</sup> of September 2018. During the discussion, the partners stressed the importance of not only measuring criteria directly linked to the mowing head but also to the site selection.

The final criteria that are taken into account during the mowing test are split into different parts:

1. Part A: Site analysis (elaborated by Delphy and CCCU)
  - a. Contamination with trash
  - b. Slope angle
  - c. Soil
  - d. Varieties of grass and other plants determination
2. Part B: Real-time analysis (elaborated by ProNatura)
  - a. Mowing height
  - b. Picture of the mowing field
  - c. Speed
  - d. Tonnage, volume of the grass
3. Part C: Grass analysis (elaborated by UGent)
  - a. Dry matter content of fresh grass
  - b. Sand content
  - c. Length of fibers
  - d. Nutrient content of fresh grass
  - e. Trace metals e.g. Pb

### Selection of an operational relevant setting

The municipality of Maldegem has experience with research projects and with different types of mowing head. The Province of West-Flanders brought Pro Natura in contact with Nico Willemarck, responsible for green services within the city.

Three years ago the municipality of Maldegem bought a Herder with horizontal rotary mowing head in combination with a Deutz Fahr tractor and a Record loader. The investment is a result of a research project also related to different methods of mowing.

In total, the municipality has circa 700 km of roadside verges to be mowed every year. 20% of the verges are mowed with their own equipment and 80% is under procurement by a third party. In the Flemish Region, the management of roadside verges is regulated by the Berm Decreet (Roadside Act). The mowing period cannot start before the 15<sup>th</sup> of June and must end the latest by the 15<sup>th</sup> of October. Only with an approved management plan, a deviation is allowed. The municipality Maldegem does not have a management plan for the roadside vergers. They consider the cost too high and see no benefit so far because they do not need an exemption of the mowing dates.

Every stretch is mowed 2 times: summer and autumn. During the summertime, some stretches are only mowed one mowing line 1.2 m wide. During autumn, the total verge is mowed. The mowed grass is directly blown into the loader, a bulk container attached to the tractor. The mowed material is dropped off at the green waste facility of the municipality or at the IVM park at Eeklo (depending on opening hours, not in morning and evening = closed)

The municipality mows with their own equipment in two shifts from 6h till 14h and from 14h till 21h.

Before the 15<sup>th</sup> of June, they first mow other green sites in the municipality such as sport and football fields and green spaces in parks and public areas.

The city once worked with a public procurement for mowing with specific criteria. One contractor had the bid and worked with his own developed mowing head. But at the end evaluation, it did not meet the standards set by the municipality.



*The Herder Eco mower of the municipality of Maldegem*

The city of Maldegem and Pro Natura discussed possible locations for a relevant operation setting. 2 sites were selected where 2 combinations could be equally evaluated and compared:

1. Verge along road of the Leopoldskanaal, Dijkstraat Maldegem
  - Advantage: real-life situation, grassy verge, interesting for evaluation of plant regrowth after cutting in verge, long stretch to compare two combinations.
  - Disadvantage: along a public road, passing traffic.
2. Open space behind sports club between Zandakkers en Ringbaan.
  - Advantage: On the site trees are present, also a slope both representing real challenges during roadside cutting process. Large grass field available for different stretches.
  - Disadvantage: Uniform grass species (from seeding a couple of years ago, not representative for the diversity in a real roadside). Not a real-life setting.



*Location 1 at Leopoldskanaal*



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*Location land Zandakker - Ringbaan*



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Final selection of the site: Dijkstraat, Maldegem. Roadside verge of 2,4 km



### Mowing head selection

During the mowing test, a newly designed mowing head of Vandaele was tested against the Eco mower of Herder.

The Herder mower is a horizontal rotary mower and was developed during a former project, Interreg NWE Combine.

### *Vandaele flail mower*



Description and pictures of the Vandaele mowing head can be found in D1.1.1. Development of mowing head.

*Herder horizontal rotary Eco mower*



The mowing head is composed of two horizontal rotating disks. On each disk, retractable knives are attached in case a hard object like a stone is hit.

The horizontal rotation of the knives results in a clear cut on the set cutting height. This yields a mix of shorter and longer fibres of the plants cut. If cut in a verge where the grass is quite high, this could result in a large number of long fibres that could block the suction pipe to the bulk container. To prevent blocking the pipe, a small flail rotation device is installed in front of the entrance of the pipe to limit the size of the fibres.



The mowing head has 1.6 m of width, while a normal one has 1.2m, which results in a bigger area to be cut during the first mowing rotation. The operators like the head for its good manoeuvrability, as it is easy to work around obstacles like trees. Lesser work is needed to be done with a hand mower to clear obstacles.

The evaluation of the municipality of Maldegem after three years of using a Herder rotary mower has positive and negative aspects:

+ *Positive*

Can be used with very low sucking power, good for ecology, insect life, less dirt, and very low sand content.

- *Negative*

Very slow combination, 3-5 km/h

Cannot easily handle long fibres, they can block the tube. It was decided to install a small flail just in front of the tube to cut the grass in smaller particles.

Investment cost is high:

Head 20 000 Euro

Total combination: head, tractor, loader: 200 000 to 250 000 Euro.

The municipality of Maldegem criteria to choose for the Herder combination are mainly ecological.

The horizontal rotary mowing head with low sucking capacity will result in a nice clean cut, leaves insects unharmed and can handle the litter in the roadside verges. Plants and grass recover very quickly after mowing in comparison with a flail mower that destroys more the flora.

## Mowing test results

The test took place on the 18<sup>th</sup> of June 2019 in the Dijkstraat in Maldegem along a roadside verge with a total length of 2.4 km, of which 2 km were to be mowed. The verge was divided into equal sections of 200 m and 300 m each for every combination. Each mowing head mowed 2 sections of 200 m and 2 sections of 300 m. On every section, 2 cuts were performed with the mowing head.

### Part A: Site analysis

- **Botanic composition of the roadside**

Only plants that are overwhelming are considered. Plants that appear sporadically are not counted but are written down as an observation. The number of overwhelming plants is expressed in percentage.

- **Soil analyses**

- Manual observation

The soil is made a bit loose and its structure is judged. The finding is expressed in words.

- Deeper granular analyses

A 10 cm sample in 3 repetitions is taken 2m from the road, where possible. Samples are analysed for soil quality (organic matter, pH, texture).

- **Slope angle**

The slope angle is measured by a Dutch app on the mobile phone (Android): Waterpas. The phone is held in the angle of the slope, so you can read the angle from the app.

- **Pollution**

This is scored in 4 different categories per square meter:

Extremely contaminated: >5 Objects

Contaminated: 2-5 objects

Clean: 1-2 objects

Very Clean: <1 object

The objects are seen as things that do not belong on a roadside (like cans, cigarettes etc.)

- **Carrying capacity**

A metal pin (or another sharp object) is introduced in the ground around 50cm from the road. The depth the pin goes in the ground is then recorded in cm.

Because of the way roads are built, there is a concrete layer of rubble under the roadside. Therefore, using a Penetrometer is not representative because it will give a wrong image of the compaction in the soil.

On 26 April 2019, Dominique Cammaert, researcher at Delphy, assessed the site on Dijkstraat in Maldegem on various parameters. These observations (shown on the "Observations" tab of this document) were performed at 10 locations at a length of 2.5 km. By using the described methods, she has come to the following conclusions per parameter:

- **Botanical composition of the roadside**

The site generally contains the following plants: Cow Parsley (*Anthriscus sylvestris*), Dandelion (*Taraxacum officinale*), Corn buttercup (*Ranunculus arvensis*), catch weed (*Galium aparine*), stinging nettle (*Urtica dioica*), Seedlings of Poplars (*Populus x canadensis*). Sporadic other weeds were found.

- **Soil analyses**

The soil had a sandy structure and was dark in colour. The dependence of soil quality with the distance from the road can be seen in the table below:

	<b>0.5 m from road</b>	<b>4 m from road</b>
<b>soil texture</b>	loamy sand	sandy loam
<b>% sand</b>	77.7 ± 4.67	70.15 ± 2.86
<b>% silt</b>	5 ± 1.41	7.07 ± 1.89
<b>% clay</b>	17.3 ± 6.09	22.78 ± 1.77
<b>pH</b>	6.13 ± 0.21	5.05 ± 0.45
<b>EC (µS)</b>	219.7 ± 24.2	203.5 ± 86.1
<b>OM (% by weight)</b>	4.79 ± 0.74	6.27 ± 0.85

- **Slope angle**

The site has different inclination angles, depending on where the measurement is made. The slope angle was recorded from 10° to 51°, with an average of 22°.

- **Pollution**

The roadside is generally very clean. Very sporadically, something is found, but it definitely does not prevail.

- **Carrying capacity**

The carrying capacity of the roadside is good. When one tries to push a pin into the ground, one gets no more than 9 cm on average. At the bottom is a concrete/rubble layer that ensures a good carrying capacity of the roadside if machines were to run over it.

Part B: Real-time measurement of the parameters

*Visual evaluation of the difference in mowing results*



*General view of a section mowed with the Herder mowing head*





*General view of a section mowed with the Vandaele mowing head*

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On-site, there is a remarkable difference in the verge after the mowing. There is a clear distinction visible, mostly due to the different mowing heights. Vandaele could not mow lower than 10cm, while Herder was set on a height of 8 cm. In real conditions, there is a variation of 2 to 3 cm, so Vandaele could never mow lower than 8 to 7 cm and the Herder between 5-6 cm. The Herder mowing head gives a rather clear cut of the grass, often with contact of the knives with the soil.

On the pictures below, the difference can be observed. On the right, the roadside was mowed with the Herder mower. One can clearly see the distinction where the Vandaele mowing head started.



The following pictures show a comparison of the site the day of the test at the left and on the right one month later.

18<sup>th</sup> June

22<sup>th</sup> July



*Left Vandaele, right Herder*



*Front Vandaele, back Herder*



*Front Herder, back Vandaele*

On the test day of 18<sup>th</sup> June, the distinction between the two mowing heads is well visible on the ground. One month later, on the 22<sup>nd</sup> July, a distinction is no longer visible.

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## Speed

	Test A 300 m	Test B 300 m
<b>Vandaele</b>	4'45"36 3.7 km/h	4'25"57 4.07 km/h
<b>Herder</b>	5'52"89 3.06 km/h	5'30"15 3.27 km/h

The results showed, within the 2 repetitions of 300 m, that Vandaele is 1 minute, or 1 km/h, faster on such small tests.

## Tonnage, volume of grass

The bulk container of the Herder could hold 12 m<sup>3</sup>, just enough for 1 cut over the total length of 1 km. Therefore, it had to unload before starting the second cut.

The bulk container of Vandaele had 25m<sup>3</sup> and was estimated by the operator to be 90% full after completing the two cuts.

## Part C: Quality of the grass

The figure below shows grass clippings obtained with the circular and the flail mowers. Regarding the macroscopic characteristics, it was possible to observe that the circular mower generated longer fibres than the flail mower.



*Fresh grass clippings obtained with the circular mower (left) and the flail mower (right)*

## Dry matter content and sand content

UGent took samples of the grass mowed by Vandaele and Herder and analysed the dry matter content and the sand content.

	Dry matter content	Sand Content (DM)
<b>Vandaele: Flail mower</b>	27% ±3%	2.8% ±0.8%
<b>Herder: Circular mower</b>	39% ±7%	8.7% ±2.2%

Grass clippings obtained with the flail mower had a slightly higher moisture content than those obtained with the circular mower:  $73 \pm 4\%$  and  $61 \pm 7\%$ , respectively.

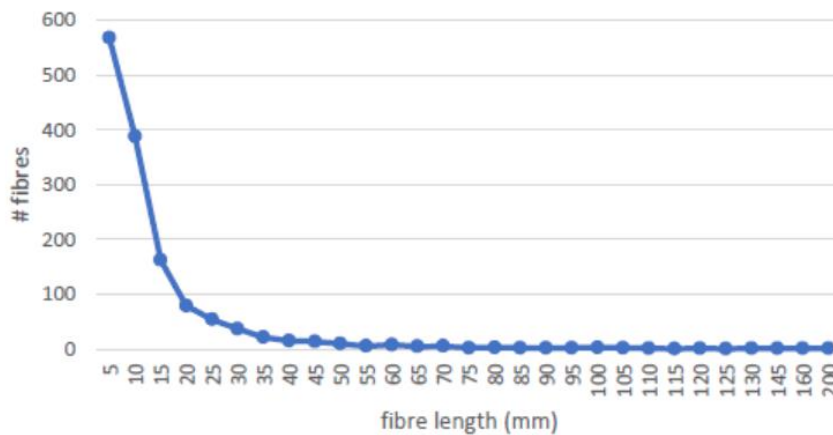
The flail mower was more efficient in producing less contaminated grass clippings, resulting in a sand content of  $2.9 \pm 0.8\%$  in comparison to the circular mower, which yielded clippings with  $8.7 \pm 2.2\%$  sand content.

### Fibre length

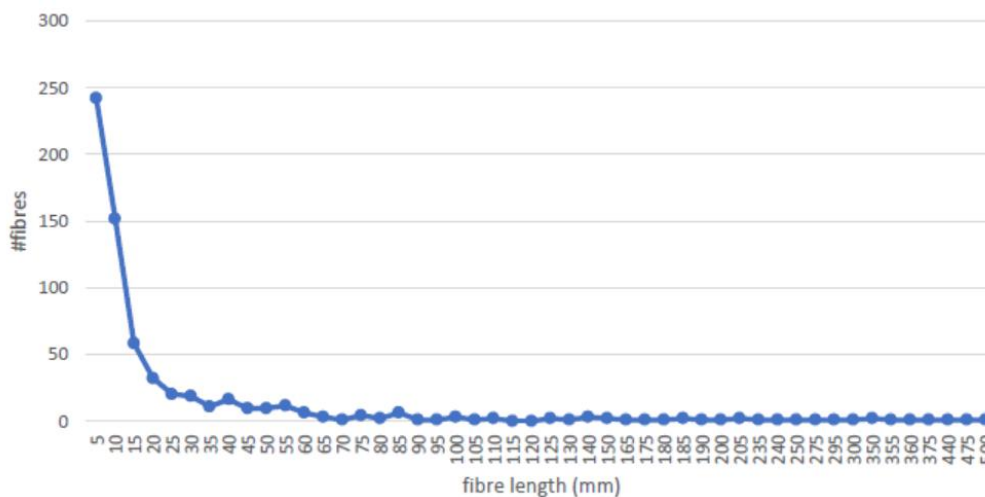
The total average length, omitting the fraction of fibres  $< 4\text{mm}$ , was calculated to be:

- 13.6 mm for the modified flail mower
- 28.5 mm for the circular mower

The graphs below depict the fibre distribution; the X-axis shows the fibre lengths in steps of 5mm, missing datapoints are not shown.



### Vandaele mowing head



### Herder mowing head

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The fibre distribution mentioned below refers to fibres shorter than 4mm, longer than 20mm, and fibres assigned to a class with an average length of 5, 10 and 15 mm. Grass seed and poplar leaf debris were assigned as a separate class.

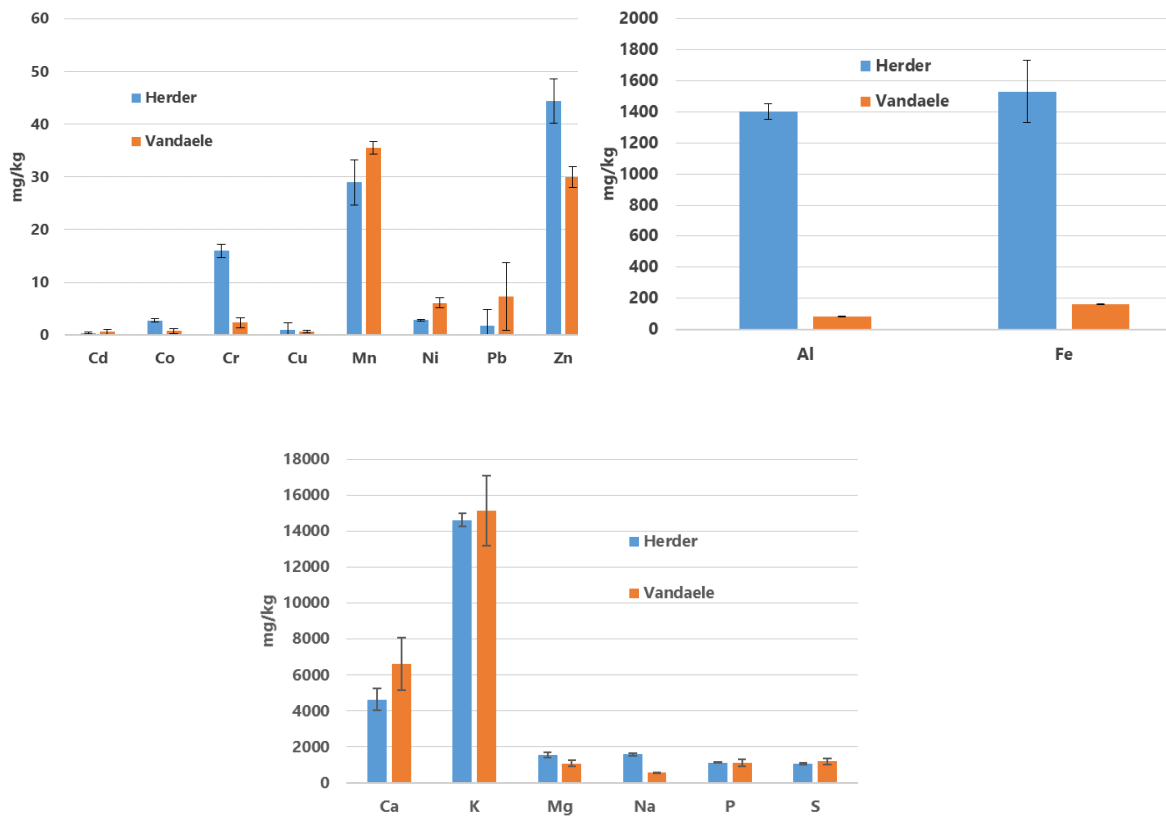
*Fibre length (mm) distribution Vandaele mower (weight percentage)*

F < 4	F5	F10	F15	F ≥ 20	Leaf/seed
10,4%	6,2%	7,3%	8,0%	59,7%	8,4%

*Fibre length (mm) distribution Herder mower (weight percentage)*

F < 4	F5	F10	F15	F ≥ 20	Leaf/seed
8,9%	0,9%	1,6%	5,6%	76,3%	6,7%

*Trace metals and nutrients*



*Elemental composition of grass clippings obtained with the different mowing heads*

Most of the elements were found in similar concentrations in both grass samples, with the exception of Aluminium, Copper, Chromium, Iron, Nickel and Zinc. However, most of these were in the same order and magnitude and the differences could be attributed to improper sampling, as only a small amount of clippings were characterized out of a much larger amount that was mowed. Only Chromium, Aluminium and Iron displayed difference in the order of

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magnitude found for their concentrations, with the grass clippings from the Herder mower displaying higher levels than the ones from the Vandaele mower.

## **Conclusions and lessons learned for the testing and comparison of the newly developed mowing head and the Eco mower**

Low soil and sand content is one of the critical criteria for the high-end use of grass clippings in the biorefinery production chain. The flail mowing head from Vandaele yielded clippings with a much lower sand content than the ones obtained with the Herder mower. Together with the lower sand content, the lower concentration of heavy metals in the grass clippings obtained with the Vandaele mower could be an indication of the better suitability of this equipment over the Herder mower for obtaining grass clippings for further processing.

## Appendix

### Appendix 1: Site analysis Dijkstraat 26/4/2019

	x	y	Onkruiden	Hellingshoek in °	grondsoort	Indringing in cm	vervuiling
1	51.23632779440124	3.4444293629065967	Kleefkruid, zuring, brandnetels, boterbloem, populier zaailingen	18	zand	10	erg schoon
2	51.23622838081564	3.443860693368394	Paardenbloem, fluitenkruid, boterbloem, zuring	17	zand	10	erg schoon
3	51.23632903059624	3.4391301103431764	fluitenkruid, populier zaailingen, brandnetels, paardenbloem	15	zand	10	erg schoon
4			paardenbloem, brandnetels, zuring	51	zand	5	erg schoon
5	51.236584175459875	3.438259926780727	Populier zaailingen, brandnetels, zuring, paardenbloem	20	zand	5	erg schoon
6	51.236579376731996	3.4379736858263463	Brandnetels, populier zaailingen, paardenbloemen	24	zand	10	erg schoon
7	51.23749801515643	3.4337810633237873	bramen, fluitenkruid, populier zaailingen, brandnetels, kleefkruid	15	zand	10	erg schoon
8	51.23909426857457	3.42712439076405	populier zaailingen, brandnetels, kleefkruid, fluitenkruid	21	zand	5	schoon
9	51.23968455396276	3.424807412758443	boterbloem, populier zaailingen, brandnetels	27	zand	20	erg schoon
10	51.24174163161143	3.4188464829488843	Bramen, brandnetels, fluitenkruid, kleefkruid	10	zand	5	erg schoon
				22		9	
	<b>Overige waarnemingen</b>						
	sporadisch afval						
	sporadisch herik, klavers						
	veel zaailingen van populieren						
	De site is gelegen aan een drukke weg						
	langs de kant van de weg ligt een kleine laagte, water afvoer						



## GRASSIFICATION consortium

Project No. 2S03-014:



With the financial support of



[www.interreg2seas.eu/en/grassification](http://www.interreg2seas.eu/en/grassification)