Fast-track Use Case implementation – Permanent Grassland

Quick user guide

Introduction

In most countries, permanent grasslands are defined through the set-up of a minimum time range of persistence (e.g. 5 years). Most countries also define a reference date or period for the mowing of these permanent grasslands. In Italy and Spain (two of our pilot countries), the mowing date is not the driving element for the definition of permanent grasslands, but rather a set of activities that contribute to have the grassland in a "good state" (e.g. grazing, boundaries elements, mowing date or mowing within an agronomic year, etc.).

The implementation of the "Permanent Grassland" use case is focused on the detection of mowing events during the reference periods defined by the national regulations.

Sen4CAP Earth Observation product supporting the Permanent Grassland use case

The specific product that has been developed to support the analysis of farmers' declaration compliancy is the "**L4B – Grassland mowing product**". The aim of the product is to provide the information about grassland mowing events over the LPIS or GSAA polygons declared by the farmers as permanent grassland in a given region or country.

The main challenge in developing a methodology for this use case is dealing diverse national implementations, which can give less or even no importance to grassland mowing events.

When the Permanent Grassland definition is more driven by specific activities that maintain the grassland in a good state, a similar approach than the one developed for the "**L4C – Agricultural Practices monitoring product**" could be foreseen. For the moment, this product cannot be used as it is focuses on parcels declared with Ecological Focus Area practices.

Agriculture Practice Definition

During the initial phase of the project, the Paying Agencies of all pilot countries have been asked to provide their national definition of Permanent Grassland. When mowing events were part of the definition, they were also asked to define the reference or mandatory periods (e.g. according to Single Area Payment Scheme (SAPS)) during which these events should be observed. The example of such a form is presented below (Netherlands).

Figure 1: Example of form shared with Pass to collect information on national regulations (Netherlands)

NETHERLANDS		
Grassland Crop List of permanent grassland crops (crop codes, according to national crop legend) that are of interest for mowing detection		
Crop type (code, name)		
265, Grassland, permanent		
331, Grassland, natural. Main function of agriculture.		
336, Grassland, natural. Area with a nature management type that is predominantly used for agricultural activities CAP		
... Add\modify if necessary		
National regulations National regulations to assess the compliancy of grassland mowing. The regulations are specified for each crop, if different		
Crop type (code, name)	**Mandatory mowing period. Please specify the mandatory period for mowing**	**Additional rules in case of mowing event is outside the mandatory period. Plaese specify the compliancy or not (C or NC), depending on 2 cases: 1) Compliant (C) or not compliant (NC) if a mowing event occurred in the mandatory period and also**
265, Grassland, permanent	At least 1 mowing between 1st April and 31st October	1) C 2) NC
331, Grassland, natural. Main function of agriculture.	At least 1 mowing between 1st April and 31st October	1) C 2) NC
336, Grassland, natural. Area with a nature management type that is predominantly used for agricultural activities CAP	At least 1 mowing between 1st April and 31st October	1) C 2) NC
... Add\modify if necessary	*... Add\modify if necessary*	*... Add\modify if necessary*
General information about mowing practices		
Indicative mean umber of mowing events during the agronomic year (e.g.: one, multiple, ...)	3	
Common period of mowing (e.g.: from April to October)	April - October	
Main practice (e.g. mowing or grazing, ...), eventually specify the crop type	Both: Mowing and grazing (all grassland crop). For ground truth: this will be specified.	
Additional comments	1. Farmers in the Netherlands are encouraged to graze cattle. They get paid extra for the milk. So grazing cattle is very common in the Netherlands. 2. NL has in Rural Development some practices in with a ban on mowing in a certain period. In those cases a notification is made with the date of mowing. This date is an indication, because it is about the whole area. At this moment we do not know whether we have such farmers in the research group (ground truth), but as this specific use case concerns mowing detection, research group will be sufficient for this use case I guess.	

The detailed description and explanation of temporal rules for each particular practice can be found in Annex A.

Satellite data indicators

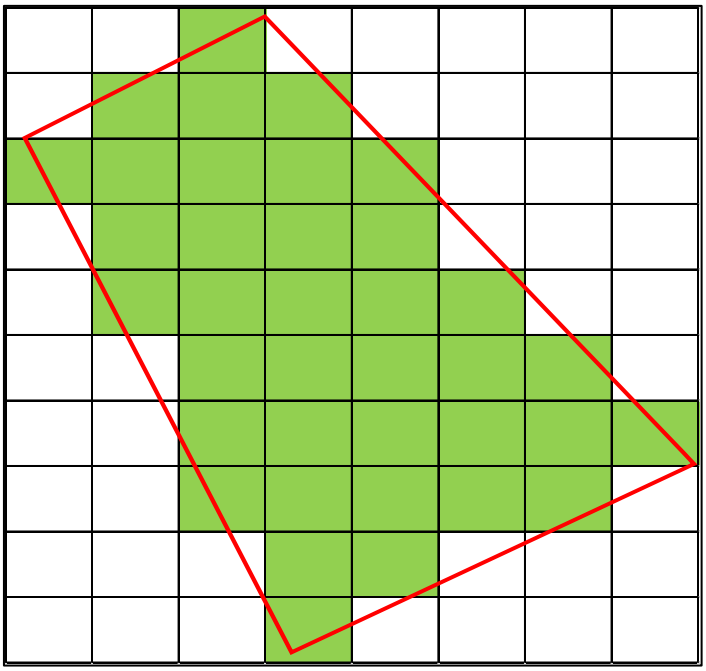
The developed methodology relies on the analysis of dense temporal profiles over the parcels for which permanent grassland has been declared. The generation of temporal profiles is based on Synthetic Aperture Radar (SAR) Sentinel 1A/1B imagery and on optical Sentinel 2A/2B imagery.

The SAR-based indicators include calibrated SAR backscattered amplitude (square root of the linear sigma nought) and coherence at 20 m spatial sampling, for ascending and descending orbits and for VV and VH polarizations.

The optical-based indicators include Vegetation Indexes (VI) as Normalized Difference Vegetation Index (NDVI), Leaf Area Index (LAI), fraction of Absorbed Photosynthetically Active Radiation (FAPAR) at 10 m spatial sampling.

The parcels are processed considering, as valid pixels, all pixels having the centroid falling in the parcel, without apply any inner buffer (no touch approach). Therefore the algorithm processes all parcels having at least 1, S2 or S1, valid pixel (no touch approach).

Figure 2: Example of valid pixels (green)) for the parcel (red) according to the no touch approach



Control approach

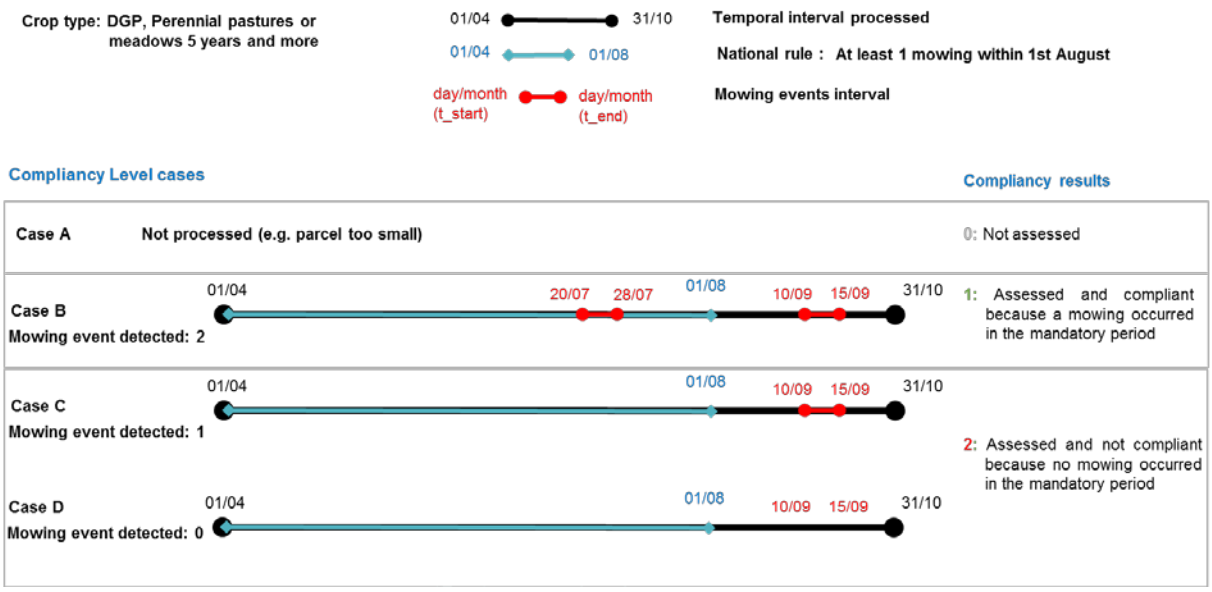
According to the national reference or mandatory periods and rules, it is possible to assess to each parcel a “compliancy” level, depending on occurrence/not occurrence and date of mowing event detected. The compliancy level domain [0, 1, 2] is based on the following criteria:

- "0": Not assessed (if the parcel has not been processed as, for example, for overlapping or for parcel size/shape considering that the algorithm processes all parcels having, at least, 1 pixel whose centroid falls inside the parcel boundaries)
- "1": Assessed and compliant because a mowing occurred in the reference period
- "2": Assessed and not compliant because no mowing occurred in the reference period

Because of the algorithm works on temporal series, having a frequency of about 6 days for SAR data and, on average, 5 days for optical data (excluding cloud cover impact), the mowing event is provided as temporal interval (t_start, t_end) in which the mowing event occurred.

The compliancy is assessed evaluating if the temporal interval of the mowing detected “intersects” the temporal mandatory period or interval of the specific crop, as represented in the figure below.

Figure 3: Description of criteria adopted for compliancy assessment (DGP crop, LTU)



Results

The resulting L4B Agricultural practices monitoring product consists of an ESRI shapefile containing the parcels that were monitored and describing for each parcel, the number and the dates of each mowing event detected. The files are delivered with a README document to describe the content of each data column.

Therefore the product shapefile includes, for each parcel, the following attributes (see Annex B at the end of the document):

- Data representing the input for the analysis:
  - Unique identifier of the parcel (NewID)
  - Original Holding identifier (ori_hold)
  - Original parcel identifier (ori_id)
  - Original declared agriculture crop type (ori_crop)
- Specific fields (if any) requested by PA, coming from the original GSAA (e.g. for Czech Republic as CTVREC and ZKOD_DPB)
- Results of the analysis:
  - number of mowing events detected on the whole period analyzed (mow_n)
    For n that can vary from 0 to a maximum of 4 mowing events:
    - temporal interval (m*n*_dstart, m*n*_end) in which, sometimes, the mowing event occurred: m*n*_dstart represents the last date, from available data, on which the mowing has not yet been detected and m*n*_end represents, from available data, the date when the mowing event has been detected
    - reliability flag given in terms of probability of right mowing (m*n*_conf)
    - satellite mission data used for detection of mowing (m*n*_mis)
  - flag (compl), providing the results about compliancy or not with country regulations and reasons (e.g.: no mowing occurred in the mandatory reference period)

For what concerns the confidence level (m*n*_conf), since the grassland mowing detection is based on a threshold criterion, the confidence is estimated by calculating how much the thresholded index is higher than the threshold itself and then normalizing this quantity (between 0 and 0.5 for detection based on S1 and between 0.5 and 1 for detection based on S2). For instance:

- for detection based on S2 optical multispectral data, the confidence is the normalization (between 0.5 and 1) of the difference VI(tcf) - VI(t) – thVI , where:
  - VI(tcf) is the last cloud-free sensed Vegetetation Index (VI),
  - VI(t) is the current VI value
  - thVI is the threshold.
- for detection based on S1 SAR data (coherences), the confidence is the normalization (between 0 and 0.5) of the difference Cohe(t=T0-T-1) - Cohe_fit(t=T-1-T-2) - thCOHE, where:
  - Cohe(t=T0-T-1) is the coherence between the current S1 acquisition and the previous one,
  - Cohe_fit(t=T-1-T-2)) is the coherence between the previous S1 acquisition and the one before
  - thCOHE is the threshold.

After the calculation of the confidence level of each mowing event detected with both S1 and S2, the algorithm “sorts” them based on confidence level itself and selects those with higher confidence level, up to a maximum of 4 mowing events.
This selection takes also in account that the minimum interval between 2 mowing events (mx_dstart-m(x+1)_dstart) is larger than 28 days, assuming that two consecutive mowing cannot be too much close.

An example of the results is provided below.

Figure 4: Example of Grassland Mowing Product shapefile attribute table

NewID	ori_id	ori_hold	ori_crop	mow_n	m1_dstart	m1_dend	m1_conf	m1_mis	m2_dstart	m2_dend	m2_conf	m2_mis	m3_dstart	m3_dend	m3_conf	m3_mis	m4_dstart	m4_dend	m4_conf	m4_mis	compl
507672	31.0000003469685.001	200249643	265	1	2019-05-26	2019-07-25	0,763	S2	0	0	0	0	0	0	0	0	0	0	0	0	1
507675	31.0000003481744.001	200623613	265	3	2019-05-13	2019-05-18	0,938	S2/S1	2019-05-18	2019-06-25	0,876	S2/S1	2019-07-27	2019-08-24	0,931	S2/S1	0	0	0	0	1
507677	31.0000003483387.001	202335826	265	1	2019-08-19	2019-08-21	0,746	S2	0	0	0	0	0	0	0	0	0	0	0	0	1
296373	31.0000003884539.001	40224047	265	2	2019-05-13	2019-06-07	0,848	S2/S1	2019-07-25	2019-07-30	0,51	S2	0	0	0	0	0	0	0	0	1
507679	31.0000003444572.001	203544961	266	4	2019-04-21	2019-05-13	0,894	S2/S1	2019-06-17	2019-06-27	0,894	S2/S1	2019-07-23	2019-07-29	0,391	S1	2019-08-31 10:	2019-09-10	0,853	S2/S1	1
496830	31.0000003896820.001	203616084	265	3	2019-04-23	2019-05-11	0,86	S2/S1	2019-06-17	2019-06-25	0,857	S2/S1	2019-07-27	2019-07-30	0,844	S2/S1	0	0	0	0	1
169661	31.0000004015639.001	204063760	266	3	2019-05-13	2019-05-19	0,5	S1	2019-06-10	2019-06-25	0,846	S2	2019-06-25	2019-07-27	0,901	S2/S1	0	0	0	0	1
507682	31.0000003470514.001	201309636	265	3	2019-04-21	2019-04-27	0,5	S1	2019-05-13	2019-06-07	0,763	S2/S1	2019-07-17	2019-07-25	0,584	S2	0	0	0	0	1
507683	31.0000003470517.001	201309636	265	2	2019-04-21	2019-05-11	0,888	S2/S1	2019-06-07	2019-06-27	0,863	S2/S1	0	0	0	0	0	0	0	0	1
170622	31.0000003927465.001	204556959	265	2	2019-04-23	2019-05-11	0,727	S2/S1	2019-06-17	2019-06-25	0,784	S2	0	0	0	0	0	0	0	0	1
264511	31.0000004182090.001	211846025	265	2	2019-05-13	2019-06-07	0,518	S2	2019-07-02	2019-07-27	0,816	S2	0	0	0	0	0	0	0	0	1
507687	31.0000003472340.001	80074847	265	1	2019-05-18	2019-06-17	0,572	S2	0	0	0	0	0	0	0	0	0	0	0	0	1
507688	31.0000003472346.001	80074847	265	1	2019-06-25	2019-06-30	0,552	S2	0	0	0	0	0	0	0	0	0	0	0	0	1
92796	31.0000003988781.001	30095225	266	2	2019-05-12	2019-05-18	0,5	S1	2019-05-28	2019-07-27	0,876	S2	0	0	0	0	0	0	0	0	1
507689	31.0000003472956.001	204540909	265	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
670887	31.0000003982196.001	201097965	266	1	2019-04-23	2019-05-13	0,846	S2/S1	0	0	0	0	0	0	0	0	0	0	0	0	1
507690	31.0000003473644.001	202328080	265	1	2019-05-12	2019-05-18	0,5	S1	0	0	0	0	0	0	0	0	0	0	0	0	1
258347	31.0000004050968.001	201217833	265	2	2019-06-17	2019-07-27	0,517	S2	2019-09-10	2019-09-13	0,501	S2	0	0	0	0	0	0	0	0	1
507691	31.0000003473647.001	202328080	266	2	2019-06-25	2019-07-02	0,772	S2	2019-08-11	2019-08-17	0,5	S1	0	0	0	0	0	0	0	0	1
507692	31.0000003474468.001	200729961	265	3	2019-05-13	2019-05-18	0,614	S2	2019-06-07	2019-06-30	0,576	S2	2019-07-30	2019-08-24	0,635	S2	0	0	0	0	1
536288	31.0000003658236.001	201219453	265	3	2019-05-18	2019-05-24	0,23	S1	2019-07-17	2019-07-25	0,927	S2	2019-09-09	2019-09-15	0,458	S1	0	0	0	0	1
507693	31.0000003474476.001	200729961	265	3	2019-05-11	2019-05-17	0,308	S1	2019-06-17	2019-06-30	0,587	S2	2019-07-30	2019-08-24	0,859	S2/S1	0	0	0	0	1
659225	31.0000004032384.001	201252845	265	1	2019-07-17	2019-07-25	0,556	S2	0	0	0	0	0	0	0	0	0	0	0	0	1
507694	31.0000003484639.001	203902880	265	1	2019-05-31	2019-07-05	0,767	S2/S1	0	0	0	0	0	0	0	0	0	0	0	0	1
225514	31.0000003623987.001	204731861	265	3	2019-04-30	2019-05-06	0,464	S1	2019-05-13	2019-06-25	0,804	S2/S1	2019-07-30	2019-08-14	0,718	S2	0	0	0	0	1
507695	31.0000003484641.001	203902880	265	1	2019-05-12	2019-05-18	0,5	S1	0	0	0	0	0	0	0	0	0	0	0	0	1
193400	31.0000003986757.001	203670194	265	3	2019-04-23	2019-05-11	0,764	S2	2019-06-30	2019-07-27	0,575	S2	2019-08-26	2019-09-20	0,759	S2	0	0	0	0	1
507696	31.0000003484642.001	203902880	265	1	2019-05-31	2019-06-30	0,625	S2	0	0	0	0	0	0	0	0	0	0	0	0	1
507698	31.0000003484714.001	203898051	265	2	2019-06-16	2019-06-22	0,398	S1	2019-07-25	2019-07-31	0,344	S1	0	0	0	0	0	0	0	0	1
507701	31.0000003484725.001	203898051	265	2	2019-04-21	2019-05-13	0,875	S2/S1	2019-06-17	2019-06-23	0,5	S1	0	0	0	0	0	0	0	0	1
292480	31.0000004052148.001	201248578	332	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
507703	31.0000003485816.001	201187348	266	2	2019-05-13	2019-06-27	0,839	S2/S1	2019-07-17	2019-07-30	0,519	S2	0	0	0	0	0	0	0	0	1
611485	31.0000003453137.001	40265881	265	3	2019-04-23	2019-05-13	0,757	S2	2019-06-07	2019-06-27	0,782	S2	2019-08-26	2019-08-31	0,798	S2	0	0	0	0	1
507705	31.0000003485841.001	201187348	266	1	2019-04-29	2019-05-05	0,409	S1	0	0	0	0	0	0	0	0	0	0	0	0	1
682899	31.0000004133826.001	201730060	265	2	2019-05-13	2019-05-19	0,373	S1	2019-07-27	2019-07-30	0,697	S2	0	0	0	0	0	0	0	0	1
507706	31.0000003485887.001	203687156	265	2	2019-05-12	2019-05-18	0,5	S1	2019-06-17	2019-06-27	0,912	S2/S1	0	0	0	0	0	0	0	0	1
507707	31.0000003485890.001	203687156	265	2	2019-05-13	2019-06-07	0,58	S2	2019-08-21	2019-08-24	0,566	S2	0	0	0	0	0	0	0	0	1
24203	31.0000003591737.001	204315524	265	4	2019-05-13	2019-06-02	0,781	S2	2019-06-17	2019-07-02	0,815	S2	2019-08-26	2019-09-15	0,794	S2	2019-09-20 10:	2019-10-15	0,779	S2	1
507708	31.0000003461286.001	203767107	265	4	2019-05-11	2019-05-17	0,5	S1	2019-06-11	2019-06-17	0,5	S1	2019-07-17	2019-07-25	0,746	S2/S1	2019-09-08 10:	2019-09-15	0,608	S2	1

Figure 5: Example of Grassland Mowing Product shapefile visualization

Figure 6: Example of Grassland Mowing Product, classified according to the compliancy value ("0": Not assessed (grey parcels), "1": Assessed and compliant because a mowing occurred in the reference period (green parcels), "2": Assessed and not compliant because no mowing occurred in the reference period the reference period (red parcels))

Annex A: Description of national mowing regulation and control approach for pilot countries for 2019

Table 1. Czech Republic grassland mowing regulations

Country: Czech Republic		
Crop type (ori_crop, name)	**Mandatory mowing period**	**Compliancy domain**
315, Temporary Grassland	At least 1 mowing or grazing within 31st July	Compliancy domain [0, 1, 2] • "0": Not assessed • "1": Assessed and compliant because a mowing occurred in the reference period • "2": Assessed and not compliant because no mowing occurred in the reference period
350, Permanent Grassland		
3001, Permanent Grassland		

Table 2. Lithuania grassland mowing regulations

Country: Lithuania		
Crop type (ori_crop, name)	**Mandatory mowing period**	**Compliancy domain**
GPŽ, Pasture or meadow, perennial grass up to 5 years	At least 1 mowing or grazing within 31st July	Compliancy domain [0, 1, 2] • "0": Not assessed • "1": Assessed and compliant because a mowing occurred in the reference period • "2": Assessed and not compliant because no mowing occurred in the reference periodthe reference period
DGP, Perennial pastures or meadows 5 years and more	At least 1 mowing or grazing within 31st July	
GPA, Pasture or meadow, perennial grass up to 5 years, renewed in the current year	At least 1 mowing or grazing within 31st July	
EPT, Extensive meadows grazing with livestock	At least 1 grazing between 1st May and 30th October	
SPT, Specific meadows	At least 1 mowing between 15th July and 15th October	
5PT-2, Extensive management of wetlands (direct payments are paid	At least 1 mowing between 15th July and 1st March (next year)	
MNP, Aquatic warbler habitats storage in raw and semi-natural grasslands	At least 1 mowing or grazing between 1st July and 1st October	
MNS. Aquatic warbler habitats storage in wetlands	At least 1 mowing or grazing between 1st August and 1st October	

Table 3. Italy grassland mowing regulations

Country: Italy		
Crop type (ori_crop, name)	**Mandatory mowing period**	**Compliancy domain**
46, Loietto Loglio	At least 1 mowing or grazing between 1st April and 31st October	Compliancy domain [0, 1, 2] • "0": Not assessed • "1": Assessed and compliant because a mowing occurred in the reference period • "2": Assessed and not compliant because no mowing occurred in the reference period
51, Lupolina		
65, Grassland		
79, Vetch		
152, Clover		
336, Meadow		
389, Vetch species		
390, Vetch species		
460, Grassland with orchid		
461, Herbal species		
562, Alpha-Alpha		
581, Annual grassland		
612, Annual grassland		
800, Annual grassland		
840, Annual grassland		
862, Fenugreek		
899, Permanent grassland		

Table 4. Spain grassland mowing regulations

Country: Spain		
Crop type (ori_crop, name)	**Mandatory mowing period**	**Compliancy domain**
2, Alfalfa 85, Grassland pasture	At least 1 mowing or grazing between 1st April and 31st October	Compliancy domain [0, 1, 2] • "0": Not assessed • "1": Assessed and compliant because a mowing occurred in the reference period • "2": Assessed and not compliant because no mowing occurred in the reference period

Table 5. Romania grassland mowing regulations

Country: Romania		
Crop type (ori_crop, name)	**Mandatory mowing period**	**Compliancy domain**
450, Temporary grassland (artificial, sowed on AL < 5 years) 603, Public permanent grasslands used in common 604, Permanent grasslands used in common 605, Public permanent grasslands used individually 606, Permanent grasslands used individually 607, Individually used meadows 608, Public meadows used individually 609, Pasture individual 610, Pasture shared 611, Hay shared mowed 612, Pasture communal but used individually 660, Traditional orchard extensively used by pasturage and or mowing 661, Traditional orchard extensively used as meadow 662, Energy natural meadows 663, Orchard traditional extensive pasture 671, Convert sensitive PP	At least 1 mowing between 1st May and 31st October	Compliancy domain [0, 1, 2] • "0": Not assessed • "1": Assessed and compliant because a mowing occurred in the reference period • "2": Assessed and not compliant because no mowing occurred in the reference period

Table 6. Netherlands grassland mowing regulations

Country: Netherlands		
Crop type (ori_crop, name)	**Mandatory mowing period**	**Compliancy domain**
265, Grassland, permanent	At least 1 mowing between 1st April and 31st October	Compliancy domain [0, 1, 2] • "0": Not assessed • "1": Assessed and compliant because a mowing occurred in the reference period • "2": Assessed and not compliant because no mowing occurred in the reference period
266, Grassland temporarily		
331, Grassland, natural. Main function of agriculture		
332, Grassland natural. Main function nature.		
333, Edge adjacent to permanent pasture or permanent cultivation consisting mainly of permanent grass.		
334, Edge adjacent to land mainly consisting of permanent grass. (EA: not managed).		
370, Edge adjacent to permanent pasture or permanent cultivation mainly consisting of temporary grass.		
372, Edge adjacent to land mainly consisting of temporary grass. (EA: not managed).		
383, Grass seed.		
1921, Grass sods.		
3506, English raaigrass		
3509, Festulolium		
3512, Italianraaigrass		
3513, Westerwoldsraaigrass		
3519, Sorghum		
3522, Timothee		
3523, Veldbeemdgras		
3805, Rietzwenkgras industrial grass		
3807, Rietzwenkgras other than for industrial grass		
3808, Roodzwenkgras		

Annex B: Description of ESRI shapefile attibutes

1. NewID: Unique Parcel ID
2. ori_hold: Holding ID
3. ori_id: Original Parcel ID
4. ori_crop: Code of crop type selected as grassland.
5. mow_n: Number of mowing. Values domain: 0, 1, 2, 3, 4.
6. m1_dstart: Date representing the start date of the time interval in which the mowing n° 1 is occurred (if any).
7. m1_dend: Date representing the end date of the time interval in which the mowing n° 1 is occurred (if any).
8. m1_conf: Reliability flag given in terms of probability of right mowing n° 1 detection (if any).
9. m1_mis: Satellite mission data used for detection of mowing n° 1 (if any). Values domain: S1, S2, S1/S2 or S2/S1
10. m2_dstart: Date representing the start date of the time interval in which the mowing n° 2 is occurred (if any).
11. m2_dend: Date representing the end date of the time interval in which the mowing n° 2 is occurred (if any).
12. m2_conf: Reliability flag given in terms of probability of right mowing n° 2 detection (if any).
13. m2_mis: Satellite mission data used for detection of mowing n° 2 (if any). Values domain: S1, S2, S1/S2 or S2/S1
14. m3_dstart: Date representing the start date of the time interval in which the mowing n° 3 is occurred (if any).
15. m3_dend: Date representing the end date of the time interval in which the mowing n° 3 is occurred (if any).
16. m3_conf: Reliability flag given in terms of probability of right mowing n° 3 detection (if any).
17. m3_mis: Satellite mission data used for detection of mowing n° 3 (if any). Values domain: S1, S2, S1/S2 or S2/S1
18. m4_dstart: Date representing the start date of the time interval in which the mowing n° 4 is occurred (if any).
19. m4_dend: Date representing the end date of the time interval in which the mowing n° 4 is occurred (if any).
20. m4_conf: Reliability flag given in terms of probability of right mowing n° 4 detection (if any).
21. m4_mis: Satellite mission data used for detection of mowing n° 4 (if any). Values domain: S1, S2, S1/S2 or S2/S1
22. compl: Compliancy flag. Value domain: 0, 1, 2 according to the following rules:

    - "0": Not assessed
    - "1": Assessed and compliant because a mowing occurred in the reference period
    - "2": Assessed and not compliant because no mowing occurred in the reference period