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MAPPING OF MANAGEMENT PRACTICE ON PERMANENT GRASSLAND USING SENTINEL-2: A CASE STUDY OF NORTHERN SLOVAKIA

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Mapping of management practices on permanent grasslands using Sentinel-2: A case study of Northern Slovakia

This paper proposes a framework for identifying management practices on permanent grasslands based on a time series of remote sensing imagery. We assume that by using such an approach it is possible to check compliance with the legal conditions for granting CAP support for agricultural practices. We evaluated grassland management in the Medzilaborce region with Sentinel-2 optical satellite images. We proposed a set of indicators of mowing and grazing based on a rule-based assessment developed over a visual inspection of true color imagery as well as a phenological time series. We further used a land block database and evaluated the management using a specific traffic light system. We found that the grasslands in the studied area are managed extensively, not within time limits for granting CAP subsidies. Results suggest that this framework underestimates the proportion of the managed area of studied land blocks.

Key words: Sentinel-2, time series, Common agricultural policy, grassland, mowing, management, Slovakia

INTRODUCTION

Permanent grassland (PG) is land in permanent use (five and more years according to Eurostat 2019), not included in a crop rotation system and, which is used for the cultivation of herbaceous forage, fodder, or energy crops. Such grasslands comprise a substantial part of the agricultural land and are important for biodiversity, ecosystem services for different species, food security, carbon sequestration, and cultural heritage (Dobrovodská 2012, O'Mara 2012 and Kizeková et al. 2018). However, the persistence of these grasslands as well as the ecosystem services they provide, heavily depends on management practices such as mowing and grazing and the time of their application. (Halada et al. 2011 and Tälle et al. 2016).

Over the past three decades, the use of Slovakia's agricultural land has experienced significant changes mostly due to changes in policies, ownership patterns, and management strategies (Bezák and Mitchley 2014). Agricultural land is being used more extensively (Pazúr and Bolliger 2017), and there has also been a significant reduction in agricultural land due to abandonment or at the expense of built-up areas and recreational facilities (Kizeková et al. 2018 and Goga et al. 2020).

In the case of PG, both the Slovak Republic and the European Union protect the maintenance of agricultural activity on grasslands through the Common Agricultural Policy (CAP). Under the first pillar of the CAP, the maintenance of agricultural land is supported by direct payments (Regulation (EU) No 1307/2013). Each agricultural field on which direct payments are paid must meet the minimum requirements for the granting of direct payments according to the Government Regulation of the Slovak Republic No. 342/2014 (SGR). By applying for direct payments for grasslands, the area in question must meet the condition as fallows:

According to § 5 of Government Regulation No. 342/2014, the applicant for direct payments for parts of a land block with the type of agricultural land - permanent grassland is obliged, in the year in which the application is submitted, to maintain all areas by mowing or grazing and, additionally, by mulching according to the altitude and within the time limits specified in Annex 4 of this Regulation (Tab.1).

Tab. 1. Maintenance criteria for agricultural areas in a condition suitable for grazing or cultivation within the area's permanent grassland as defined by Annex 4 of SGR

Altitude (m a.s.l.)		0 – 400	401 – 600	601 – 800	above 800
Time limits for the first application of management	grazing	June 1	June 8	July 9	July 15
	mowing	June 22	July 8	July 29	August 8

To verify compliance with these conditions, the agricultural paying agencies carry out ‘on-the-spot checks’ on a sample of around 5% of direct payment applicants. These checks are, however, often criticized due to their limited extent, time demand, costs, and provision of only single time-spot information of the management on the parcel. Such a setup of the verification process also increases opportunities for corruption (Denník E 2018). Moreover, data that can answer questions about management type and its timing, are available only from farm statistics, and their collection is often labor-intensive and time-consuming.

As a way out, a time series of satellite imagery may provide sufficient information for continuous mapping of land use (Schwieder et al. 2020 and Pazúr et al. 2021). Several studies have already addressed the identification of agricultural practices on PG particularly, mowing and grazing. Many of them are focused only on a specific management type such as mowing (Kolecka et al. 2018, Griffiths et al. 2020 and Schwieder et al. 2022) or grazing (Ma et al. 2019). Gómez Giménez et al. (2017) in their study focused on mowing, grazing, and fertilization, however, their approach cannot address specific dates of management. Primarily, the identification of the management activities on PG using optical imagery is based on the changes in the reflectance as measured with the satellite sensor. After the application of agricultural management on a specific land block, its change in vegetation structure and chlorophyll production could be observed by either a time series of RGB imagery or vegetation indices. Also, radar data sources were used, such as Sentinel-1, where interferometric coherence was found particularly useful for mowing detection (Tamm et al. 2016 and De Vroey et al. 2021).

Multiple approaches can be used to map these traits, such as rule-based methods defined based on change detection (Gómez Giménez et al. 2017, Kolecka et al. 2018 and Griffiths et al. 2020). Although these approaches do not require massive numbers of ground truth data, their importance lies in the proper parametrization of what can be classified as a management practice. As an alternative, various machine learning (Dusseux et al. 2013), or deep learning (Lobert et al. 2021) algorithms have been trained, requiring a massive amount of ground truth information for proper classification and validation.

Studies dealing with PG management assessment by using satellite imagery use vegetation indices as a proxy of vegetation phenology and The Normalized Difference Vegetation Index (NDVI) is used most often (Reinermann et al. 2020). Values of NDVI range between -1 and 1, where values above 0.5 indicate the presence of healthy and dense vegetation, values close to 0 indicate bare soil and negative values indicate water areas (Pettorelli et al. 2005). Although the relationship between NDVI and green biomass is nonlinear and saturates, other vegetation indices better compensate for this problem such as the Enhanced Vegetation Index (EVI), but with lower accuracies when identifying grassland management (Halabuk et al. 2015 and Camps-Valls et al. 2021)

The Sentinel-2 satellite mission significantly increased the opportunity to continuously monitor agricultural practices (Woodcock et al. 2020). It systematically acquires optical imagery over land and coastal areas at high spatial resolution (10 to 60 meters per pixel) with a constellation with two identical satellites, Sentinel-2A and Sentinel-2B allowing a high frequency of new imagery acquisition (2 to 5 days). The open-access policy for remote sensing data, combined with open-source modern computing technologies such as cloud computing centers, allows for the exploration and monitoring of large areas of the Earth's surface in near-real-time (Casu et al. 2017). One such platform is the Google Earth Engine (GEE) consisting of petabytes of data ready for analysis and a supercomputer with parallel computation service (Gorelick et al. 2017).

Considering the availability of satellite data, processing infrastructure, and stated problems, this study aims to propose a system to evaluate permanent grassland management in light of SGR. This includes the identification of the management practices namely mowing and grazing, their timing on a pixel level, and the extent of management on the land block level. To assess the management of PG we applied our framework in a specific region and a single year, Medzilaborce district and 2019, respectively.

MATERIALS

Area of interest

The district of Medzilaborce was chosen as the area of interest for this paper due to its relatively high share of PG in the total area of agricultural land (89% of the total agricultural land in the district), according to the Slovakia Land Parcels Identification System (LPIS). The Medzilaborce district is located in the northern part of Slovakia, in the Slovak-Polish borderland. Geomorphologically, the entire district falls within the Low Beskids Mountains with an altitude from 160 m to 855 m above sea level.

In terms of climate, the NE part of the district is moderately cold, and humid with transitions to a moderately warm humid area in the SW of the district. Average annual temperatures for the area range between 4 – 8°C. In 2019, the highest temperatures were recorded in June with a mean daily air temperature around 24°C. The minimum temperature in 2019 was recorded in January with a mean daily air temperature below 0°C. The rainiest period during the described period was from the last week of April to the last week of May (Fig. 2). Less rain fell during June and rainfall in July and August could considerably affect the ability to conduct the first management practice on PG and meet conditions laid down in SGR.

Most of the region is covered by various types of Cambisoils, ranging from Dystric Cambisoils and Cambic Umbrisols in the northeast to Stagni-Eutric Cambisoils in the southwest of the study area. Planosols and Stagnosols are also present near the Laborec riverbed (VÚPOP 2000).

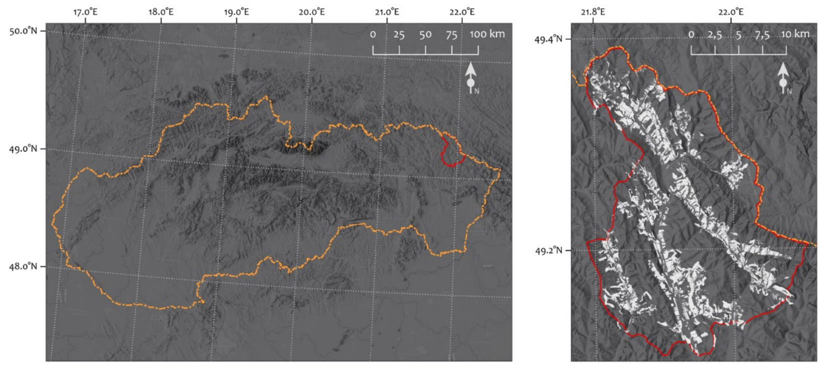

Fig. 1. Outline of the study area Medzilaborce district (solid line), located in the north-east part of Slovakia (dash line)

White polygons represent grassland parcels. Basemap: Esri Terrain.

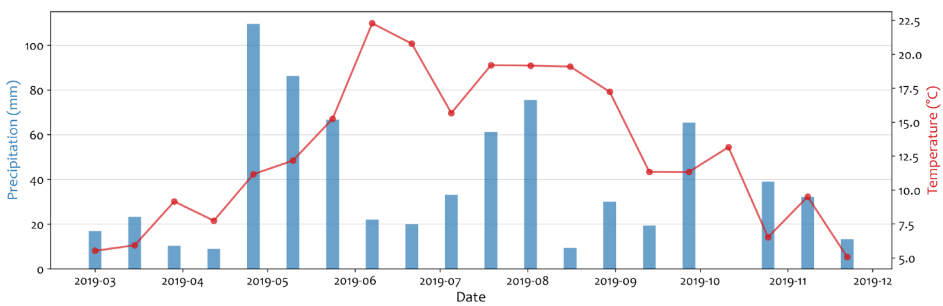

Fig. 2. 10-day mean temperature (line) and the sum of precipitation (bar) in the Medzilaborce district in 2019,derived from ERA5 Daily Aggregates

Source: Copernicus climate change service (C3S) (2017).

Data

Sentinel-2

We used Sentinel-2 images pre-processed to the Bottom of Atmosphere reflectance based on the sen2Cor algorithm implemented in the Google Earth Engine platform (GEE library COPERNICUS/S2_SR). We filtered the whole data collection based on cloud cover (less than 95%) per tile and date of acquisition (between

March 1, 2019, and November 30, 2019) – Fig. 3. Clouds were masked out with the Sentinel-2 Cloud Probability dataset (GEE library COPERNICUS/ S2_CLOUD_PROBABILITY) which estimated the pixel cloud cover probability on a scale of 0% to 100% (Zupanc 2017).

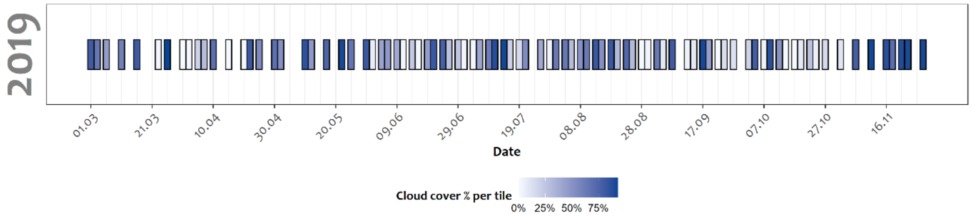

Fig. 3. Cloud cover % per tile of used Sentinel-2 imagery declared in image metadata

Furthermore, according to the visual inspection we masked out all pixels with a cloud probability value greater than 50%. Cloud shadows were masked in the interception of dark pixels selected according to the low reflectance in the near-infrared band (Sentinel-2 B8 band) and an average value of the solar azimuth angle. The *NDVI* was calculated according to Equation 1 and was chosen as an indicator of the presence of healthy vegetation.

$$NDVI = \frac{NIR - RED}{NIR + RED}, \qquad (1)$$

where *NIR* = near-infrared band and *RED* = red band.

LPIS

As part of declaring land for direct payment purposes, farmers must carefully identify the land under cultivation and exclude all uncultivated land from their claims in the GSAA application (European Court of Auditors 2016). The declared ‛Using Boundaries' (land blocks), which are based on LPIS represent the areas for the direct payments in the relevant calendar year. This is an open-access dataset, which can be downloaded from Slovak Central Public Portal People's Services (https://data.gov.sk/dataset/hranice-uzivania).

In the Medzilaborce district, 1208 parcels were declared as PG in 2019 with total area of 8 525 ha. To ensure the homogeneity of the analyzed areas, considering the resolution of the Sentinel-2 imagery, each parcel was downsized with an inner buffer of 7.07 meters. Such a buffer size was determined according to Equation 2. proposed by (Meier et al. 2020) to avoid evaluating areas consisting of mixed pixels at polygon boundaries. Also, we consider only land blocks larger than 0.5 ha, so 1 100 land blocks were analyzed.

$$Reduction\ value = \sqrt{2\left(\frac{resolution}{2}\right)^2}, \qquad (2)$$

where *resolution* = the resolution of Sentinel-2 (10 m).

The attribute table of the LPIS layer also contains information on the average altitude and average slope of the analyzed parcels. Elevations range from 207 m to 713 m a. s. l. for the highest parcel (Tab. 2).

Tab. 2. Grassland parcels parameters

	Mean	*Min*	*Max*	*StDev*
Area (ha)	7.13	0.5	159.88	13.46
Slope (°)	7.27	0.39	19.29	3.12
Altitude (m a.s.l.)	382	207	713	99.34

METHODS

Indicators of the agricultural practices

Information on the spectral response of the phenological time series after management practice on PG is necessary for its proper identification. We, therefore, developed a set of indicators of mowing and grazing based on the various criteria listed in Tab. 3. These criteria were fitted by inspecting the imagery with knowledge of the impacts of management activities on grassland cover and by visual inspection of true color imagery over selected localities.

For the identification of mowing and grazing we evaluated the local minima of NDVI followed by an increase in NDVI, as this, we considered the end of changes in phenology profiles caused by management practice. This criterion also helps us exclude seasonal changes. For grazing identification, we also consider whether the NDVI decline exceeded the threshold value before 15.7.2019, to ensure that this will be identified as grazing valid for direct payments in case there is still an ongoing NDVI decline. An illustrative real-case example of mowing and grazing indicators is provided in Supplementary 1 and Supplementary 2.

Based on the LPIS polygons, we generated 250 random points divided into training and test samples in a 70:30 ratio. On these points, we conduct a visual inspection of true color imagery as well as composited NDVI values for labeling management activities. We assume that sudden changes in grassland phenology profiles indicate mowing events (Estel et al. 2018, Kolecka et al. 2018, Griffiths et al. 2020 and Schwieder et al. 2022), while gradual changes over a longer time indicate grazing (Gómez Giménez et al. 2017 and Ma et al. 2019). Subsequently, indicators of mowing and grazing were developed according to the training set whereas the test set was used to demonstrate the accuracy and robustness of mowing and grazing indicators in this specific area. The changes in grassland phenology profiles were computed from NDVI differencing in a time lag, where every NDVI value corresponds to a 10-day time-window frame. This value was obtained by calculating the 10-day median value of NDVI.

To evaluate the management of grassland parcels, the proportion of the area on which mowing, and grazing were identified was calculated. Finally, the assessment of activities in grassland land blocks was evaluated in line with the SGR by using a "traffic light system" (European Court of Auditors 2020). The traffic light system was designed to provide an overview of the management practices based on the proportion of the managed area within an agricultural parcel. Within the traffic light system, the green color represents the parcels where at least 90% of the area was managed. The yellow color represents the parcels where management was identified on at least 30% of the area. The red color represents the parcels where management was identified in less than 30% of the area. This system was evaluated within the frame of the dates of first management set in Annex 4. to SGR, and the last considered observation for comparison.

Tab. 3. Attributes of deviations of NDVI detected after management practice on training samples

Management activity	Indicator criteria's	Specific comments
Mowing	Decrease in NDVI values between t and t-1 or t-2 records > 0.16.	Local minima of NDVI smaller than 0.16 from local maxima and constrained within 2 observations. A threshold was based on the minimum recorded deviation after the mowing event on the training sample. The next observation after the mowing event is masked.
Grazing	Cumulative decrease in NDVI value between t and t-1 until t-n records > 0.13; until 15.7. of the analyzed year or followed by NDVI increase.	A cumulative summation of negative differences of NDVI. Minimum of 3 consecutive negative differences of NDVI. The threshold was based on the minimum recorded deviation after the grazing event on the training sample.

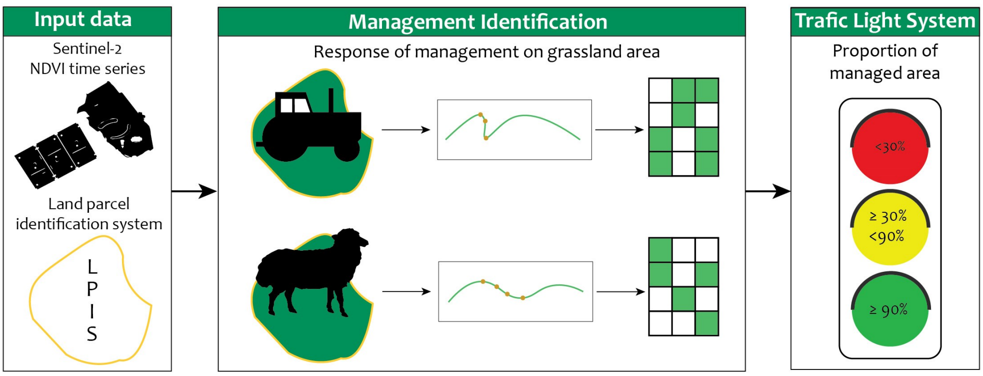

Fig. 4. The framework of grassland management identification and evaluation

Source: own elaboration.

Validation

A twofold accuracy assessment of management identification was conducted. In the first step, we evaluate the accuracy of the indicators based on a test set. Indicators were first assessed separately for mowing and grazing and then as a common indicator of management. Based on the test set we quantified the number of observations with true positivity (TP), false positivity (FP), true negativity (TN), and false negativity (FN) as well as related indices precision, recall, and F-score.

In the second step, we assessed the overall accuracy of the management identification based on the ground truth data from various on-the-spot checks, provided by the Slovak Agricultural Paying Agency. These data consist of 122 parcels, where the proportion of area was measured compared to the area declared in the GSAA application. We compare their proportion with the proportion of the managed area measured by the indicators. Based on their difference, the root means square error – *RMSE* (Equation 3) was evaluated.

$$RMSE = \sqrt{\sum_{i=1}^{n} \frac{(\hat{y}_i - y_i)^2}{n}}, \tag{3}$$

where $\hat{y}$ = managed land block proportion measured on the-spot-check, y = proportion of the managed land block proportion measured with this framework and n = the sample size.

RESULTS

Management practice identification

The resulting map (Fig. 5) shows a rather homogeneous use of PG in the Medzilaborce region. It shows that most of the grassland areas are managed by mowing once a year. Only 9% of areas were managed twice with the same management practice and another 13% of grassland areas were identified with mixed management practice (Tab. 4). Noticeably large PG areas (23%) were not identified with being managed at all.

Most of the first management practices were carried out in June and July. Only a small proportion of grassland parcels was managed during May, and surprisingly large areas were first managed in September and October (Fig. 6). Only a limited proportion of grassland areas was managed according to time limits set in SGR. The least areas managed according to time limits were identified in altitudes below 400 m, where the time limit was set in early June.

The results of the traffic light assessment indicate that more than 60% of grassland land blocks (red lights) are not managed according to date criterions set in SGR (Tab. 1). Only less than 20% of land blocks met the criteria, to maintain all areas by mowing, and grazing within time limits specified in Tab. 1, for the green light, (Fig. 7A). For comparison, regardless of the dates specified in Tab. 1, more than 75% of land blocks met the condition for the green light, and the proportion of land blocks that were assigned by red light dropped significantly to only 7% (Fig. 7B).

Tab. 4. Identification of management frequency by each indicator on the grassland's pixels

	Not applied	Once	Twice
Mowing	36%	57%	8%
Grazing	84%	15%	1%
Mixed	23%	64%	13%

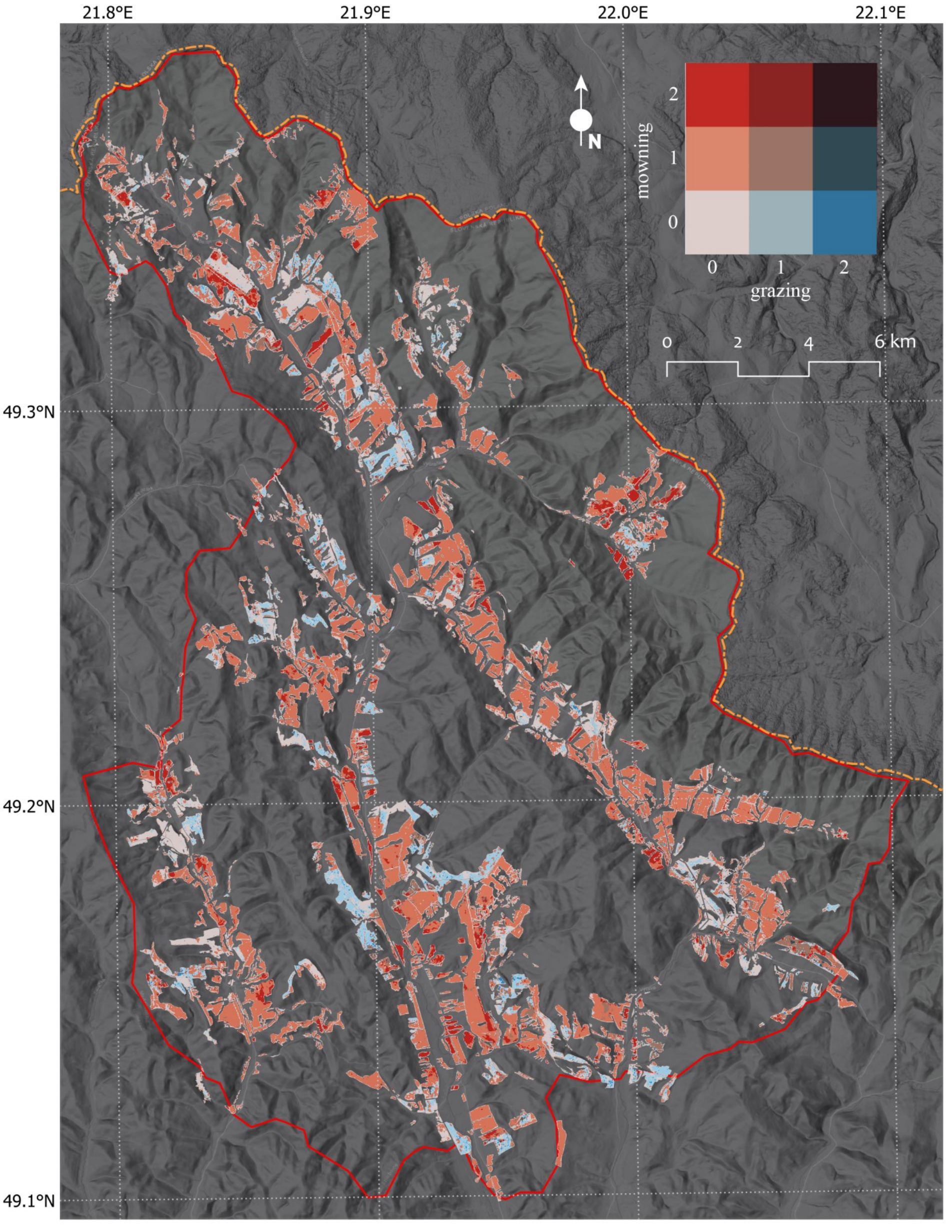

Fig. 5. Grasslands management identification in Medzilaborce region

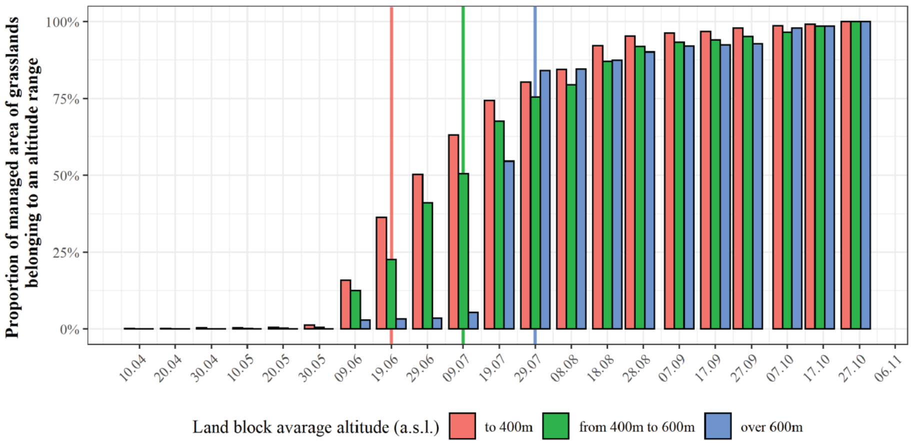

Fig. 6. Dates of the first identified management practice on grasslands
(Vertical lines refer to time limits set in government regulation).

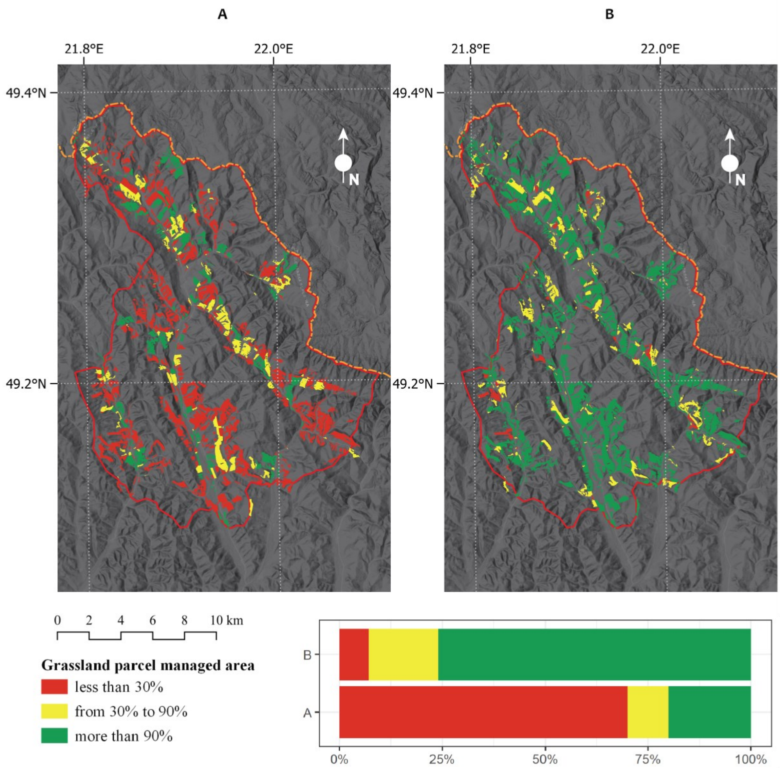

Fig. 7. Traffic light system of grassland parcels management, with bar-chart of managed area for every color and evaluated for A – the time limit set in SGR; B – for the last considered date (30.10.2019)

Accuracy assessment

Validation of identification of mowing and grazing on the test set show robustness with an f-score result of 0.92. Nevertheless, both indicators show limited accuracy in terms of precision, where (likely due to the cloud cover), a higher number of management FP cases were detected.

According to the distribution of the error in the proportion of a managed area, we found considerable underestimation of identified management (Fig. 8). This contradicts the validation set result as there were only 2 omissions recorded. Only two parcels were managed in higher proportions compared with the on-spot check. In all other land blocks, a higher proportion of a managed area was measured by the on-the-spot checks. This implies that the errors of omission are larger than the accuracy assessment the individual indicators show. The resulting RMSE shows that our measurement could differ from reality by an average of 27% per parcel.

Tab. 5. Accuracy assessment of indicators

	TP	FP	FN	TN	Precision	Recall	F – score
Mowing	65	8	1	2081	0.89	0.98	0.94
Grazing	19	4	1	2085	0.83	0.95	0.88
Overall management	84	12	2	2077	0.88	0.98	0.92

Explanations: TP – true positive, FP – false positive – FN – false negative, TN – true negative.

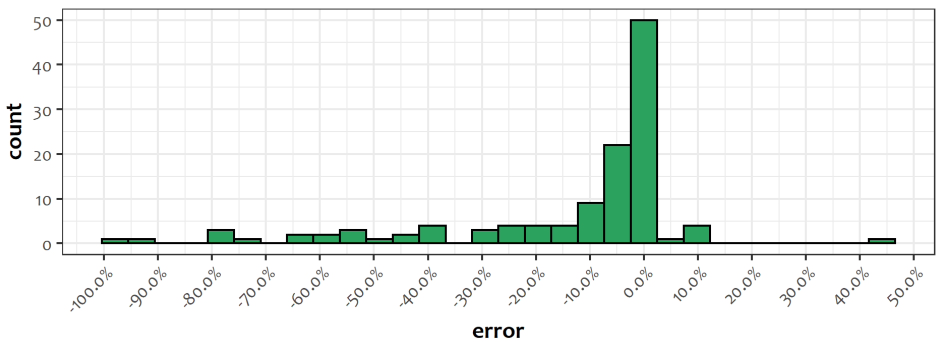

Fig. 8. Differences in the managed area proportion of grasslands land block between the measurement from the on-the-spot check and used indicators

DISCUSSION AND CONCLUSION

This study demonstrates that by using satellite imagery and cloud-computing services such as Google Earth Engine, it is possible to map management on PG at a landscape level. By coupling the Sentinel-2 time series of vegetation phenology, LPIS, and assessed knowledge of management, we were able to define indicators of mowing and grazing on a regional level in Slovakia. Such a procedure is important for the administration of CAP in Slovakia, as a similar procedure is lacking.

The indicators of mowing and grazing were developed on a pixel level. We chose this over the parcel-level approach (using the whole LPIS parcels). The reason was the high potential of the variability of different management approaches within the same LPIS block that may affect the phenological time-series data. A rule-based approach was parameterized for the region of Medzilaborce, based on visual inspections of imagery by experts on multiple selected areas. This helps us to derive assumptions about the temporal characterization of mowing and grazing on phenological time series. However, the specific parameters of indicators may differ in different years, terrain, and climate conditions. Also with this approach, we were unable to identify different livestock units.

The resulting maps of grasslands in the Medzilaborce region show low-intensity management regimes considering the frequency of management and its timing. Most of the grassland areas were managed only once per season, with only a small extent of areas with two management practices. Grassland areas were predominantly managed by mowing while grazing was identified only in 15% of analyzed areas (Tab. 4).

Surprisingly a low number of first managements was recorded in time limits set in SGR based on altitude, either on grassland areas level or LPIS land block level. These results are also reflected by the traffic light system proposed for PG parcel management evaluation in lights of SGR. The traffic light system evaluation also indicated that a significant part of the PG parcels has not been managed at all over their entire area (Fig. 7B). Nevertheless, more than 75% of the PG areas were already managed at the end of July (Fig. 6).

We found that a comparison of the proportion of the managed parcel area with measurement from on-the-spot checks show various high measurement errors, mainly an underestimation of the proportion managed area. This resulted in a 27% difference on average per parcel between results reached with our satellite-based method and field measurements. Thus, despite our parameterization of indicators being robust, there are still limitations and potential errors.

The most obvious limitation is the method of data collection for setting indicator parameters. Field data of PG management are difficult to collect in terms of time and finances. Therefore, we relied on conducting expert-based visual assessments of time series of Sentinel-2 RGB images to identify the management activities. However, extensive PG management as grazing may have gone unnoticed, creating a bias between the accuracy achieved on the test sample and the validation sample. Moreover, the grazing indicator by its definition does not include the temporal variation of the phenological curve but relies on its cumulative decrease.

Another reason for the underestimation of managed areas of PG is the temporal density of the information acquired from the Sentinel-2 image sensors. This might be partly solved by including SAR imagery such as Sentinel-1 Single Look Complex product and related indices (Tamm et al. 2016, De Vroey et al. 2021 and Atzberger et al. 2022) but it has been documented that the management practice on PG has only a minimal effect on radar backscatter, due to the small difference between the scattering from short vegetation and scattering from and soil (De Vroey et al. 2021 and Atzberger et al. 2022). Moreover, Sentinel-1-related indices are not available in Google Earth Engine, and its processing requires a significant amount of computer power.

Because similar studies have previously been limited to a single management activity (Kolecka et al. 2018, Griffiths et al. 2020 and Schwieder et al. 2022), the proposed method may be considered useful to discover information about the type of management applied. However, there is room for the improvement of grazing indicators, based on ground truth data, as some extensively grazed areas could be omitted in identification. Another possible improvement to densify the time series would be the use of other optical satellite missions such as Landsat (Schwieder et al. 2022), Planetscope (Gašprovič et al. 2018), or the use of radar missions such as Sentinel-1 (Tamm et al. 2016 and De Vroey et al. 2021), which is not affected by clouds. Also, climate and soil data should be considered in future research, especially those that can significantly affect threshold selection or rely on procedures without threshold selection (Garioud et al. 2019 and Lobert et al. 2021).

Results from this study prove the importance of mapping various management strategies on PG, using remote sensing imagery available in cloud-based platforms. Here, landscape-scale management information is unveiled, which in similar studies has been limited to a single management activity (Kolecka et al. 2018 and Schwieder et al. 2022), which enables the study of the effects of a specific management strategy on PG ecosystem services. (Halada et al. 2011, Dengler et al. 2014 and Tälle et al. 2016). We see the implication of the method used and results in reconsidering the time limits set in SGR and their suitability. Also, after sensitive parametrization of indicators, existing controlling platforms, which are less effective (e. g., farmers report, LPIS) could be supplemented.

This study presents a framework for mapping the management practices on permanent PG using the time series of Sentinel-2 phenology. Based on the visual interpretation of true color imagery of Sentinel-2, with the assessment of the impacts of management activities on grassland phenology, indicators of mowing and grazing were developed, and used in the state-of-art remote sensing platform Google Earth Engine. Using our approach, we were able to map the management type and time of its application. However extensive management regimes were not properly identified, which resulted in the underestimation of the area with identified management. Therefore, future research should rely on coupling the phenology and ground-truth data.

We found that the PGs in the Medzilaborce region are managed extensively, with a maximum of two times a season. Moreover, the observations are highly noncompliant with *§ 5 of Government Regulation No 342/2014* which lays down rules on the granting of support in agriculture in connection with decoupled direct payment schemes.

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SUPPLEMENTARY

Supplementary material can be found in this GitHub link:

https://github.com/simonopravil/Mapping-of-management-practice-on-permanent-grassland-using-Sentinel-2-on-regional-level-in-Slovakia/tree/main

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GEOGRAFICKÝ ČASOPIS / GEOGRAPHICAL JOURNAL 74 (2022) 4, 299-315

Šimon O p r a v i l, Róbert P a z ú r

MAPOVANIE SPÔSOBU HOSPODÁRENIA NA TRVALÝCH TRÁVNYCH PORASTOCH POMOCOU SENTINELU-2: PRÍPADOVÁ ŠTÚDIA ZO SEVERNÉHO SLOVENSKA

Poľnohospodárske postupy a ich špecifické časovanie sú dôležité pre zachovanie ekosystémových služieb trávnych porastov. Správne hospodárenie je preto podporované „priamymi platbami" v rámci prvého piliera Spoločnej poľnohospodárskej politiky EÚ, kde je žiadateľ o tieto platby na parcele s druhom trvalý trávny porast povinný udržiavať všetky plochy kosením alebo pasením, a to v časových limitoch podľa nadmorskej výšky. Časové rady optických satelitných snímok misie Sentinel-2 môžu poskytnúť dostatočné priestorové a časové informácie o uplatňovaných poľnohospodárskych postupoch na trávnych porastoch. Cieľom tejto štúdie je preto zhodnotiť hospodárenie na trávnych porastoch v okrese Medzilaborce podľa nariadenia vlády SR č. 342/2014 s využitím časových radov Sentinel-2 analyzovaných v programe Google Earth Engine.

V našom prístupe boli použité snímky Sentinel-2 s deklarovanou oblačnosťou menšou ako 95 % v období 1. 3. 2019 – 30. 11. 2019. Úprava snímok pozostávala z maskovania oblakov, výpočtu fenologického indexu (NDVI) a zlúčenia snímok do ekvidištančných pozorovaní na základe 10-dňového mediánu NDVI. Na rozlíšenie trvalých trávnych porastov sa použil Systém identifikácie poľnohospodárskych pozemkov (LPIS). Následne bolo vo vnútri parciel vytvorených 250 bodov, ktoré sa rozdelili na tréningové a validačné vzorky. Tréningová vzorka sa použila na návrh indikátorov kosenia a spásania a validačná vzorka na ich vyhodnotenie. Na posúdenie presnosti na úrovni parciel poskytla údaje z kontrol na mieste Pôdohospodárska platobná agentúra.

Pozorovaním časových radov NDVI a farebných (RGB) snímok boli navrhnuté indikátory kosenia a spásania na základe charakteru a veľkosti poklesu NDVI. Na posúdenie obhospodarovania trávnatých parciel bol navrhnutý systém hodnotenia pomocou semaforu založený na pomere obhospodarovanej plochy parcely.

Celkovo sme identifikovali kosenie, spásanie a ich mix na 65 %, 16 % a 9 % plôch trávnych porastov. Prvé obhospodarovanie sa vykonávalo prevažne v letných mesiacoch, boli taktiež zistené prvé obhospodarovania aj v septembri a októbri. Na základe systému semaforu bolo zistené, že iba 20 % z analyzovaných parciel splnilo podmienky podľa Nariadenia vlády SR č. 342/2014.

Hodnotenie presnosti indikátorov na validačnej vzorke poukazuje na nutnosť dôsledného maskovania oblakov pri identifikácií kosenia a spásania. Taktiež je na uplatnenie postupu v praxi potrebné vyriešiť problém z opomínania identifikácie poľnohospodárkach postupov, najmä vykonaním lepšieho zberu dát o poľnohospodárskych postupoch a zhustením časových radov.

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