Interreg CENTRAL EUROPE

Centralparks

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O.T2.1
JOINT STRATEGIC DOCUMENT ON RAISING GOOD PAs MANAGEMENT CAPACITIES

Final Version

Toolkit on innovative methods in conservation planning

09 2019

Content

1. Introduction

This summary document is based on the workshop and experience exchange about innovative nature conservation management planning tools (D.T2.1.1), that took place in Királyrét, Szokolya, Hungary between the 17th and 19th of September 2019, organized by Danube-Ipoly National Park Directorate within the framework of Centralparks Interreg CE1359 project.
The methods described in the toolkit were identified during the project preparation of Centralparks, with the goal to showcase innovative methods in nature conservation management planning.

Centralparks project

Carpathian is one of the most important European ecoregions. It is one of the European wilderness refuges, where the natural values are threatened by biodiversity loss and increasing human pressure. Traditional nature conservation is lacking to succeed in the protection of these natural values. Such issues cannot be solved by individual countries, therefore transnational cooperation was needed. The Centralparks project aims to build management capacities of Carpathian protected areas for the integration and harmonization of biodiversity protection and local socio-economic development.
One of the specific objectives set up for the project is "*improving integrated environmental management capacities of protected area administrations and other public sector entities dealing with the protection and sustainable use of natural resources*". Within the project, the Danube-Ipoly National Park Directorate aims to build capacities of Carpathian protected area managers.

Work of WPT2 – Building management capacities for protected area managers

Currently, nature conservation is lacking in human resources and expert capacities, which make long-term planning of nature conservation difficult. Mostly old-fashioned habitat mapping methods are in the every-day use of protected area managers, which need special expertise and uses a large proportion of resources. Nature conservation management planning is lacking effective, integrated, science-based information, therefore the preparation of innovative tools and methods are needed.
To face the main challenge, international cooperation and experience exchange will be built to address and share best practices in biodiversity and site management. The base of a new approach for habitat management planning will be developed through the exchange of innovative tools and methodologies for habitat mapping and evaluation. The base of the new approach consists of 3 main methods, described in this toolkit.

2. Background

National Parks in Hungary

The Hungarian nature conservation system is relatively decentralised. The hierarchically structured protection levels (natural protected areas, landscape protection areas and national parks) are managed by the 10 national park directorates in Hungary (in accordance with the number of national parks).

The nature conservation management is separated from asset management in most cases, which is particularly visible in case of forests: the areas of the forests with management plan comprise 1.940.000 ha, from which 459.000 ha are protected areas and only approximately 43.000 ha are under the asset management of the national park directorates. The forests of the protected areas are predominantly under the asset management of the 22 state forestry corporations. These rates are even less in the case of Danube-Ipoly National Park Directorate. Of the 31.400 ha of national park areas only 2.400 ha are under its asset management, from which 664 ha are forested areas. This number is a matter of particular concern, if we consider, that more than 80 % of the area of national parks is covered by forests. The reason is historical, following a similar pattern countrywide: the valuable forests in a good state were focused in one owner’s hand until the 20th century (domain of the Crown, church or nobility estates), where usually reasonable forest management is taking. In 1946, when the forests were nationalised, the forests in the good state were granted to state forestries in asset management in blocks, while the forests in poor condition and previously owned by municipalities were granted to collectives. After the establishment of the national parks the situation of the asset management changed. Later, after the regime change, only the owner structure of the collectives was changed; the forests in the protected areas were moved progressively to the asset management of the national park directorates in most of the cases, while not protected forests were privatisatized. The asset management structure of state forests and forests maintained by forestries was unvarying.

Due to these reasons, the importance of the preparation of adequate management plans together with the monitoring of management grew compared to many other Central-European asset management conditions (e.g. Poland and Germany).

For these reasons the Danube-Ipoly National Park Directorate aimed to use the following innovative methods introduced in this toolkit for the preparation of its nature conservation management plan:

The LiDAR (light detection and ranging) remote sensing technology, which will be implemented by plane, is able to give a point-cloud record constituted by ranges of distance measuring of a large area, from which relief models, surface models, tree height models and maps of clearings can be developed. On the basis of this technique, microrelief particularities can be eliminated (proceeding models, archelogy) and the storey (layers of the forest stand) can be measured. The statistical analysis and the combination of these variables with biotic data can contribute to the identification and mapping of „*hotspots*”, which are important for protected plants and animals. In Hungary, this tool was limitedly used within the fields of conservation biology. Primarily, the proceeding models (water direction within the protected lowland areas), archaeological use and tree weight appraisal (management assignment) became conspicuous.

Between 2014 and 2017 in the Börzsöny area of the Danube-Ipoly National Park Directorate under the SH4/13 project, a large-scale forest state assessment was carried out. As a result, more than 30.000 point samples regarding the forest-naturalness state were registered, which serve as a basis for every day and monitoring tasks of the national park. Connecting this database with LiDAR data will decrease the weaknesses of the two methods (the LiDAR data will be extended with several data from tree species composition, through microhabitats, to the description of shrub layer, while the forest state data will be completed with quantitative, measurement-based data). As a result a multi-aspect, broad and efficient database will be introduced, which, connected with biotic data, could help in the prediction of important points and patches concerning biology conservation and could serve as a base of itsprotection and management. With the help of the methods, areas where no data for the given species were available can be identified, **but knowing their auto-ecology, the potential preferred habitats can be indicated.**

The forest state evaluation is also potentially able to monitor the management of state forests, indicating particularly negative processes in an early phase in order to prevent further deterioration. Furthermore, the monitoring could possibly serve to achieve the nature conservation goals of the forest managers too.

In the case of the grasslands, the situation is slightly different: there is a significant amount of grasslands under the asset management of the national park directorates (also the legacy of the regime change) with no exception regarding the Danube-Ipoly National Park Directorate. Most of the grasslands are maintained by leasing contracts due to the lack of capacity and the help of local farming. The directorate monitors the grassland management to protect and develop the natural values of grassland and to amend the grasslands' state, to ensure the availability of information regarding the previous development of the area, its development factors and whether they helped or hindered the achievement of the locally appointed nature conservation goal.

3. Laser Scanning

Géza Király, PhD - University of Sopron;

3.1. Introduction

Light Detection And Ranging (LiDAR) is an active remote sensing technique, using optical wavelength (~400-1700 nm) electromagnetic radiation. The name is analogues as RADAR, but the technology is only time independent, and not weather independent. The technique often referred as Laser Scanning also. The device create a series of distance measurements in the optical wavelength. The imaging is realized through scanning, with generally very high frequency. There are several different way to range a distance, however most of the devices uses pulse ranging (or Time of Flight, TOF) method. The sensor can be put into several platforms, such as a satellite (spaceborn), to an aircraft (airborne), to a tripod (terrestrial) or to a moving terrestrial vehicle (mobile).

3.2. Spaceborne

The first spaceborne laser scanning was realized during the mission of ICESat (Ice, Cloud and Land Elevation Satellite), operated from 2003 to 2009 in the frame of the EOS program. The data of the GLAS (Geoscience Laser Altimeter System), which was operated in two different wavelength, 532 and 1064 nm, are freely available (http://nsidc.org/data/icesat/index.html). Based on the measurements of the ICESat mission a significant global forest height data were produced (Lefsky, 2010).

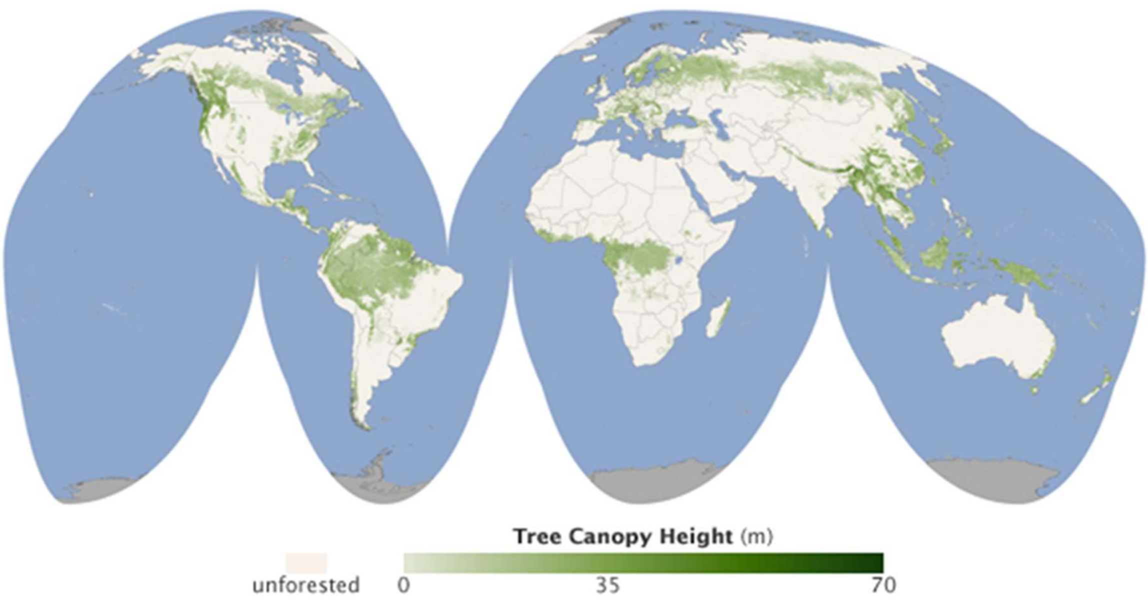

Figure 1: Global Forest Height based on data of Michael Lefsky (NASA Earth Observatory)

The ICESat-2 was launched in September, 2018. With a different ATLAS (Advanced Topographic Laser Altimeter System) sensor on board. It measures at 532 nm with 10 kHz frequency, the beam is split into 3 beam-pairs (see Figure 2).

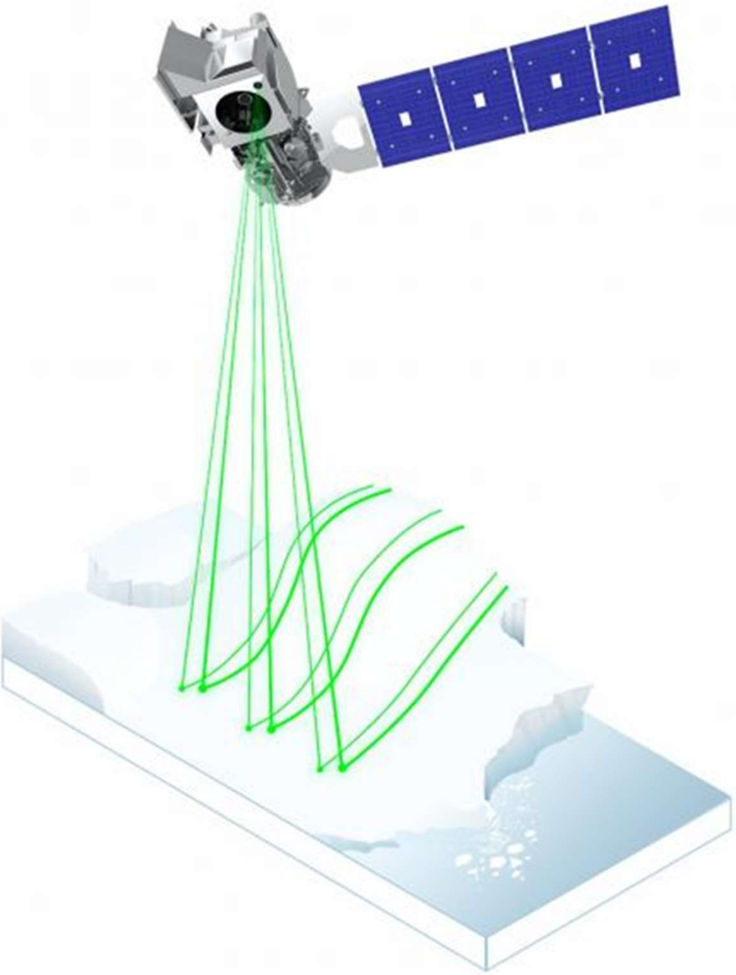

Figure 2: The ATLAS on board of ICESat-2

The data of ICESat-2 (as well as ICESat) are freely available from different sources, such as: https://openaltimetry.org

3.3. Airborne

In case of an airborne platform, the pulses are emitted in different direction. The position of the sensor is determined by GNSS, the emittance angle is recorded together with the Inertial Navigation System, so a detailed 3-dimensional point cloud is resulted during a survey (see Figure 3).

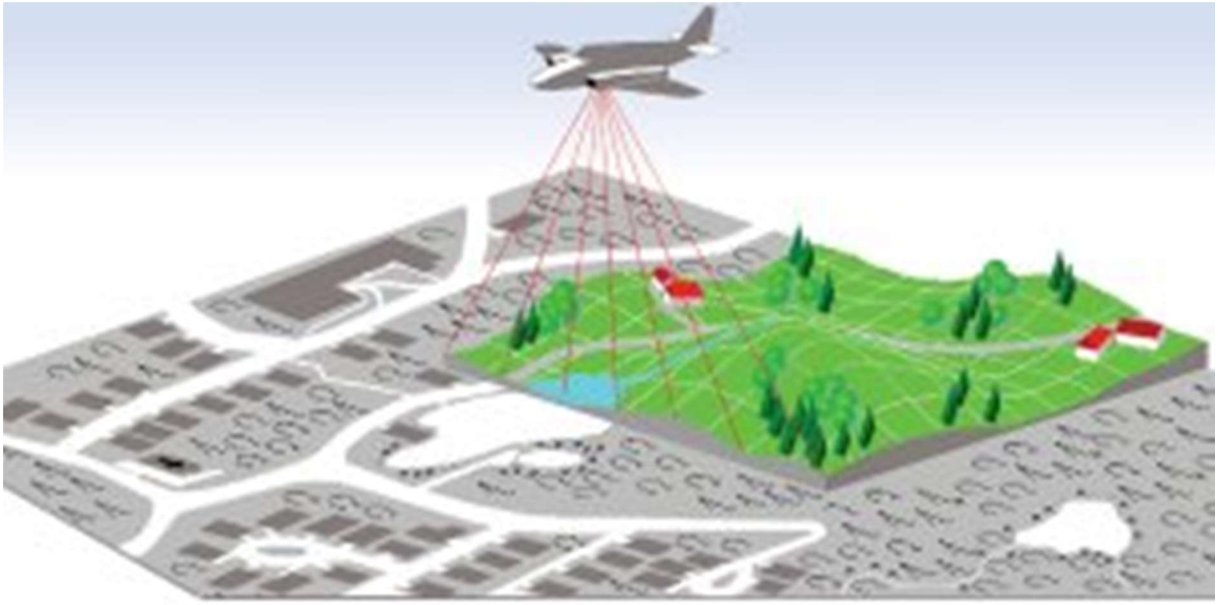

Figure 3: The method of Airborne Laser Scanning

At the beginning one returned pulse was recorded from one emitted pulse. Later the first and last return were recorded. The technological development resulted up to 6 returns from one emitted pulse.

Currently the Full Waveform (FWF) digitisation is popular for vegetation sciences, as more layers can be separated via this technique and more information on the objects can be delineated (see Figure 4).

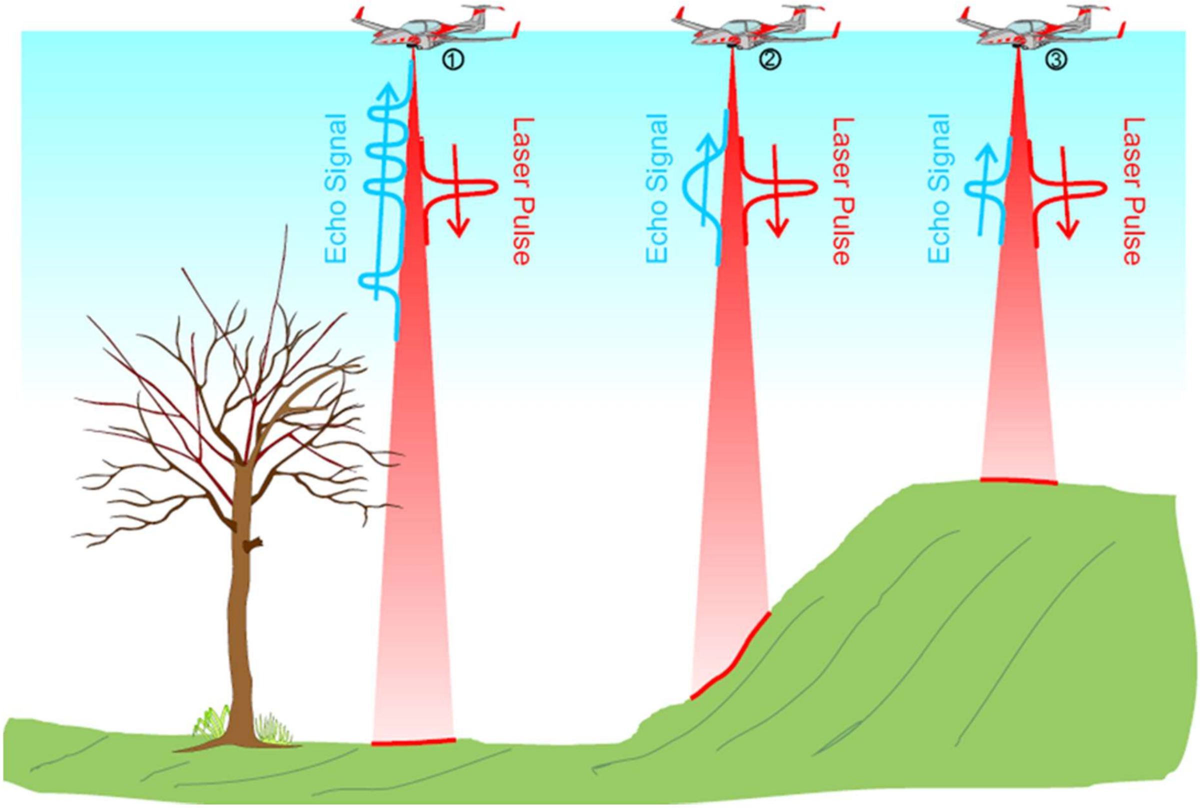

Figure 4: The theory of the full waveform digitisation

The most important application fields of the Laser Scanning are: topographic surveys, 3D City modelling, Transportation, Archaeology, Forestry, etc.

The Digital Surface Models (DSM, from first pulse), the Digital Terrain Model (DTM, from the last pulse), can be created in forestry and afterwards the normalised Digital Surface Model, or the Canopy Height Model can be calculated (see Figure 5).

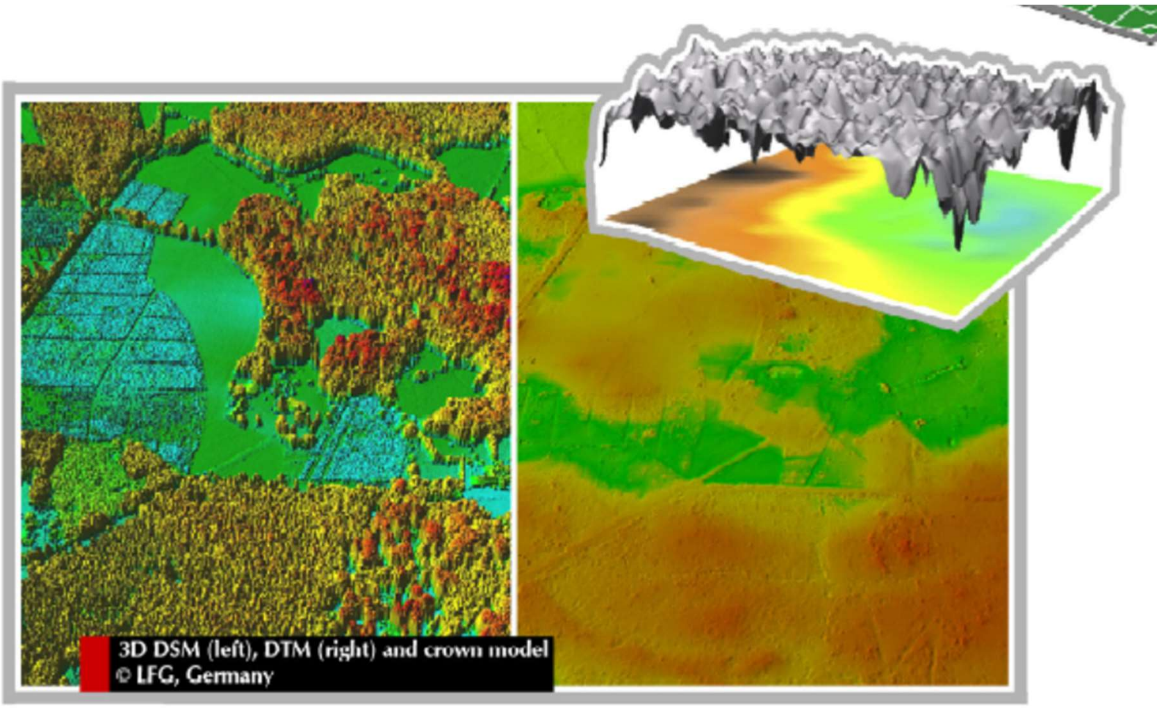

Figure 5: The Digital Surface Model (DSM on the left), the Digital Terrain Model (DTM on the right), and the Canopy Height Model in a forested area.

3.4. Data processing

The acquired raw data, which can be extremely huge, should be processed to derive some useful information.

Very important steps of the data-processing is the creation of the different elevation models, such as the digital surface end terrain model. After that the modelling of the objects of interests can be performed.

The orientation of the point cloud should be estimated and improved, if necessary. The relative orientation of the strips can be problematic, so sometimes the strip adjustment is necessary (see Figure

The strip adjustment can be performed without the trajectory data according to the publication of Ressl et al (Ressl et al. 2009) which is implemented in OPALS (https://opals.geo.tuwien.ac.at/).

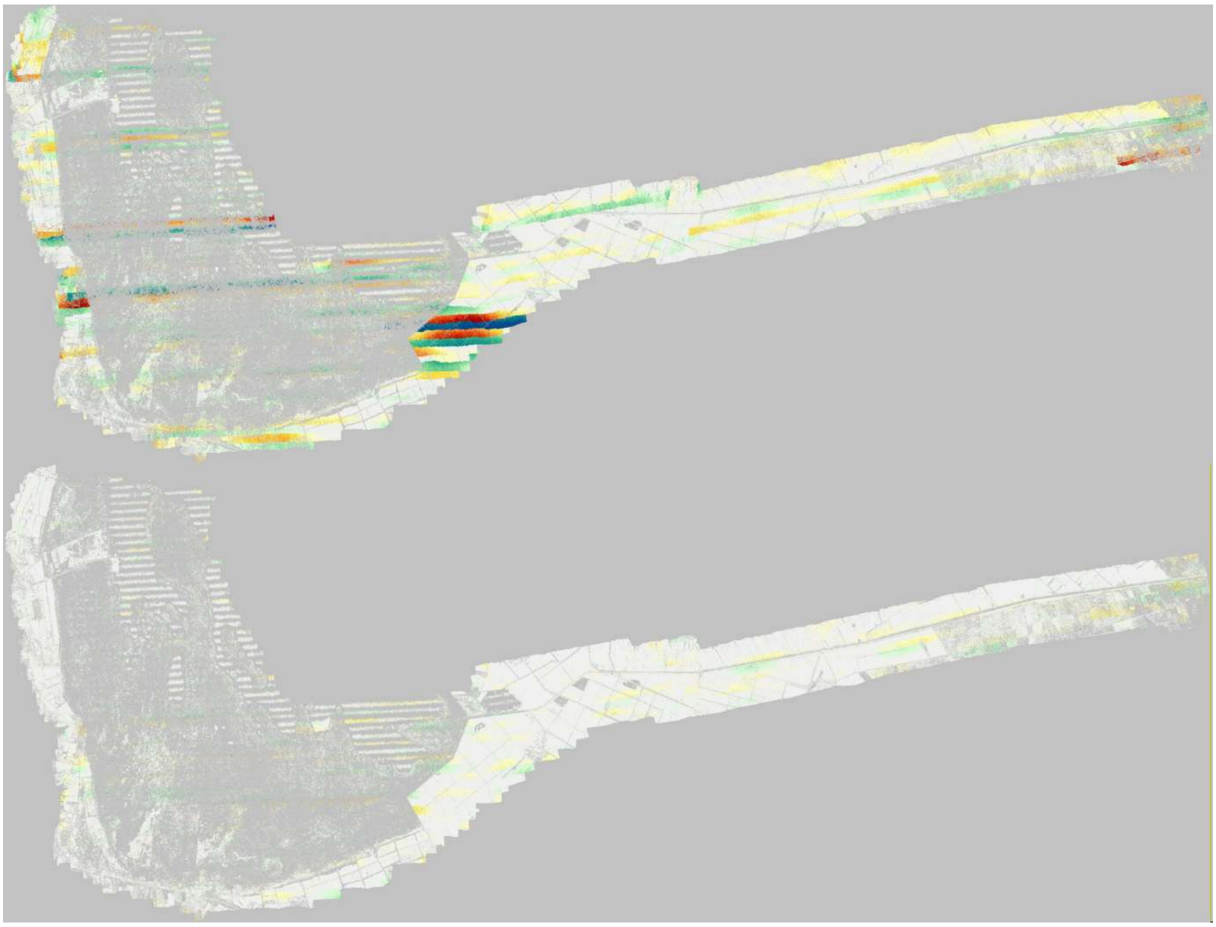

Figure 6: Deviations between the strips, before (above) and after (below) strip adjustment. Lake Fertő area

The absolute orientation of the point cloud can be performed using reference planes, such as roofs (see Figure 7).

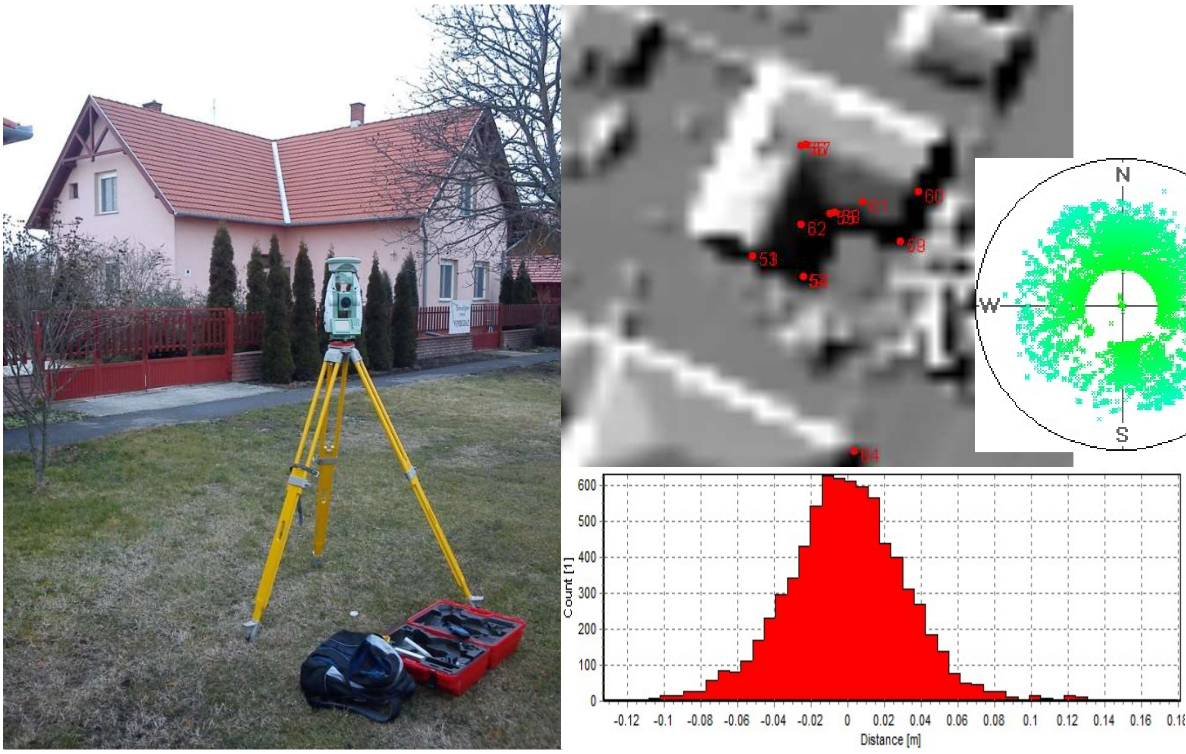

Figure 7: Reference roof measurements for absolute orientation

The filtering is an important steps to filter out noise data and to classify points reflected from the ground.

The Digital Surface Model (DSM) interpolations generally based on the highest points. The model contains buildings, vegetation and anything else detected by the laser and situated on the surface (see Figure 8).

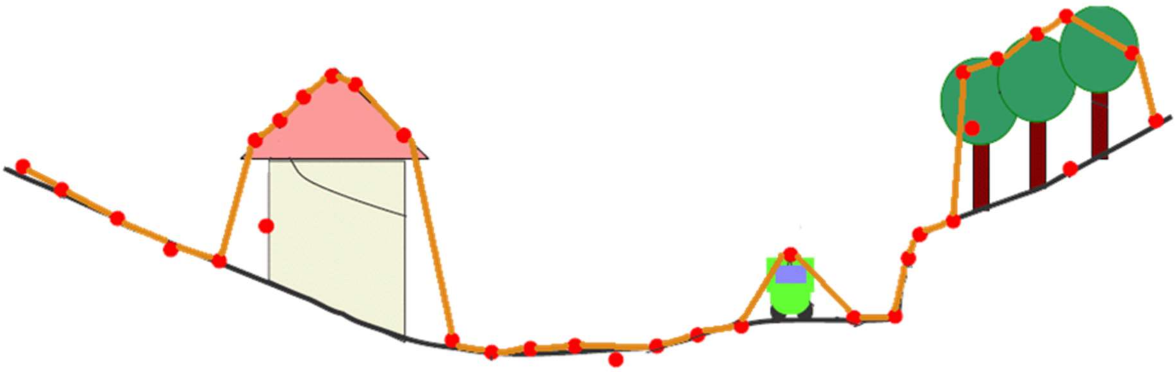

Figure 8: Demonstration of the Digital Surface Model

The most common interpolation methods for DSM generations are the followings: Nearest neighbour; Delaunay triangulation; Moving average; Moving planes; Robust moving planes; Moving paraboloid. For Forested area to describe the tree height model on a single tree level, and results near continuous surface, a maximum 2nd order polynomial interpolation method was developed (Brolly, Király, 2014). It uses a local point filtering and generate the surface model, using (maximum) 2nd order polynoms.

The Digital Terrain Model (DTM) interpolation is one of the most crucial step in data-processing. The following algorithms are the mostly used in production: Morphologic filtering; Weighting points; robust filtering; Progressive Triangulation Irregular Network; Active surfaces.

Morphologic filtering is based on Vosselmann's publication (Vosselmann, 2000).

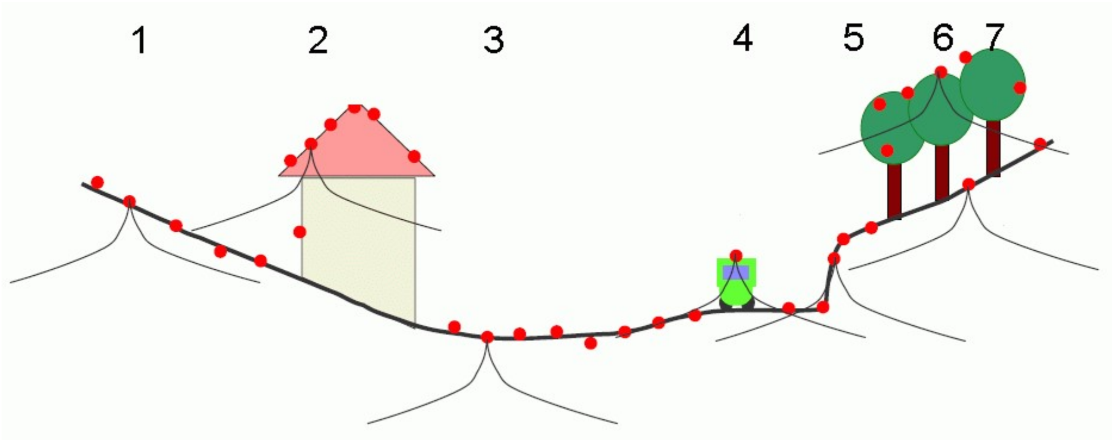

Figure 9: Demonstration of the morphologic filtering

The Weighting points gives higher weights to the points below the first draft surface (see Figure 10), and it can be quite robust in an iterative manner (Kraus, Pfeifer, 1998). This method is implemented in the SCOP++ software (https://photo.geo.tuwien.ac.at/photo/software/scop/).

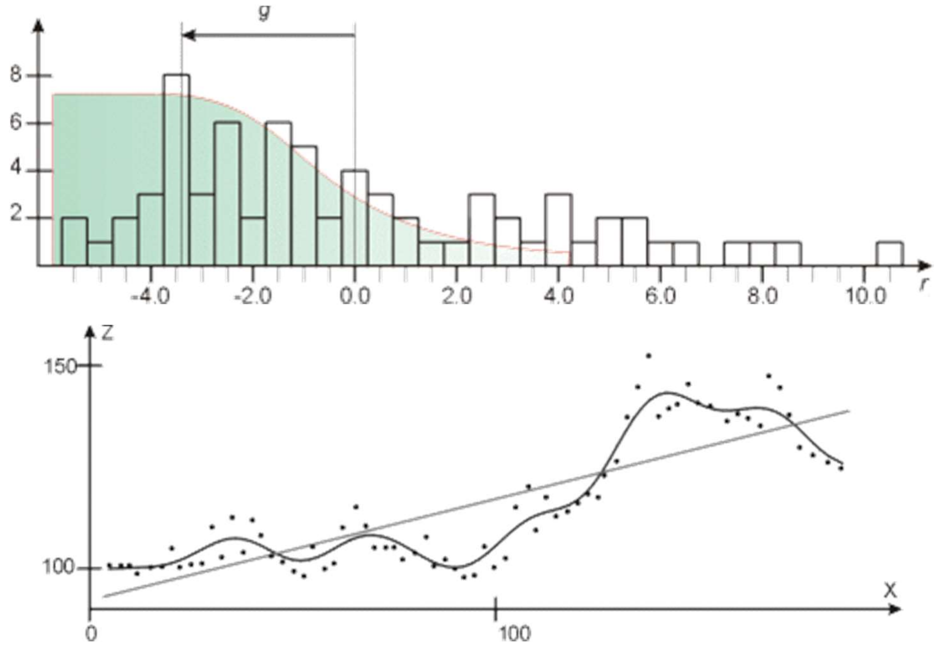

Figure 10: Weighting point

The progressive TIN (Triangulated Irreguar Network) method is a coarse-to-fine methos, where during the ‘densification’ the following parameters can be investigaetd: Slope; Iteration angle; Iteration distance; Minimum side; Reduction (see Figure 11). This method is implemented in Terrasolid (http://www.terrasolid.com/), as well as lasTools (https://rapidlasso.com/lastools/) software.

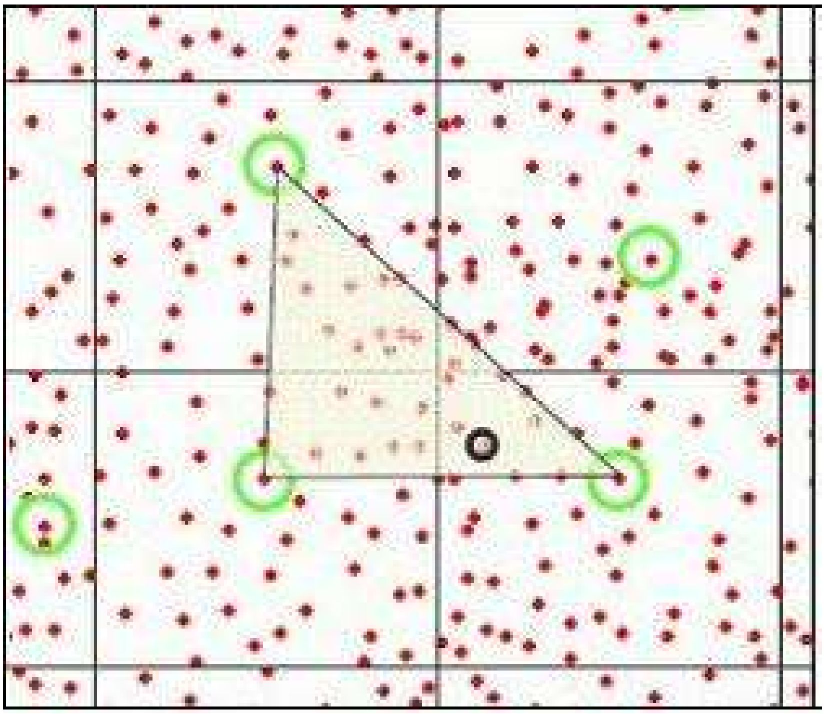

Figure 11: The progressive Triangulated Irregular Network method

The Active Surfaces method is applied in TreesVis (http://stz-felis.de/produkte/Productsheet_TreesVis_2-2.pdf) software.

After the successful DSM and DTM creation, the normalized Digital Surface Model (nDSM) can be calculated using the following formula: nDSM = DSM - DTM

This model is often referred as Canopy Height Model (CHM) in forested area. It describes the growing space of the vegetation quite precisely (see Figure 12).

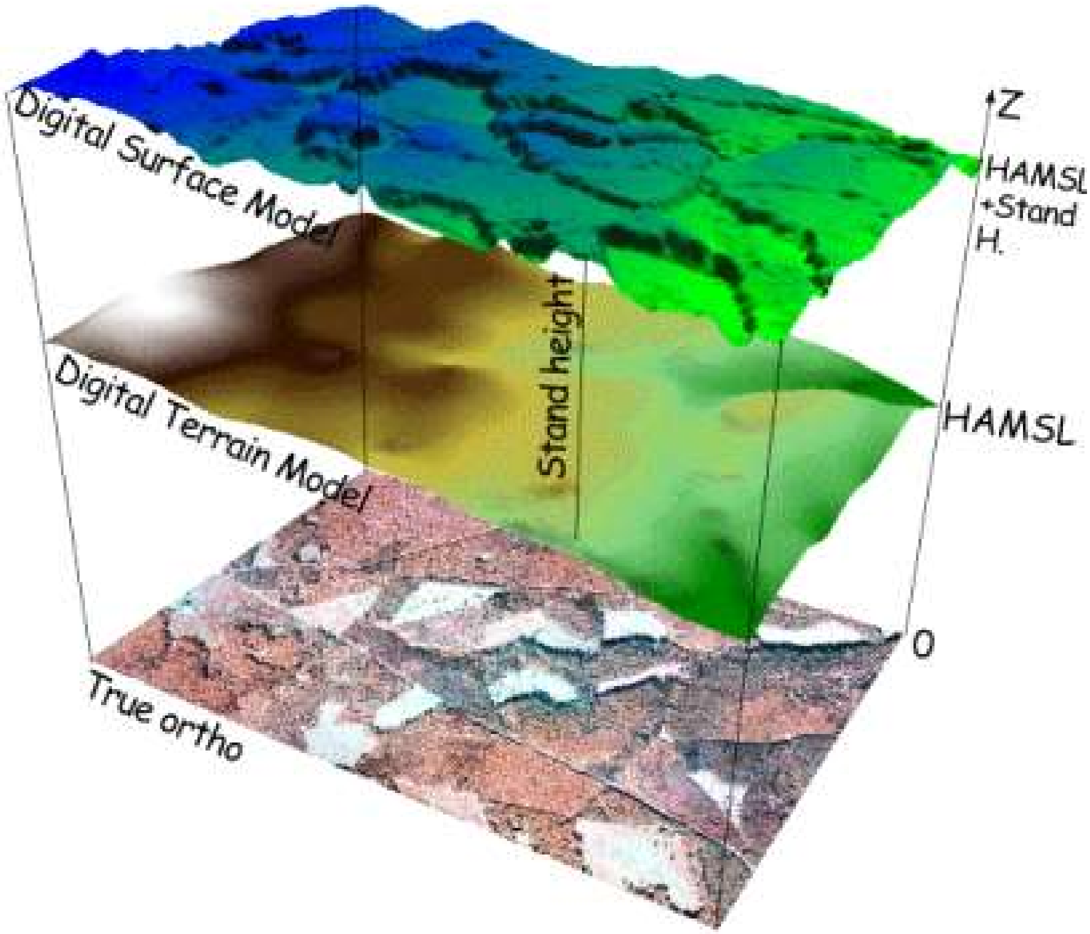

Figure 12: The different models in a forested area

$$V = F_c \cdot G_c \cdot H$$

Where:

- V: Volume
- Fc: form number
- Gc: Crown projection area
- H: Stand Height (m)

The multiplication of the later two are the growing space, which can be easily calculated using GIS. Determining the form number can result quite precise volume data of forests as well (Király et al, 2018)

References:

- Brolly, Gábor; Király, Géza (2014): Borítottfelszín-modellek (DSM) előállítása légi lézeres letapogatási adatok másodfokú felületelemekkel történő approximációjával. In: Bidló, A.; Horváth, A.; Szűcs, P. (szerk.) IV. Kari Tudományos Konferencia : Konferencia kiadvány Sopron, Magyarország : Nyugat-magyarországi Egyetem Erdőmérnöki Kar, (2014) pp. 338-342. , 5 p.
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- Ressl, C., Mandlburger, G. and Pfeifer, N., 2009. Investigating Adjustment Of Airborne Laser Scanning Strips Without Usage Of GNSS/IMU Trajectory Data. In: "ISPRS Workshop Laserscanning `09", IAPRS, Vol. XXXVIII, Part 3/W8 (2009), ISSN: 168299750; pp. 195 - 200.
- Vosselman, G. (2000): Slope Based Filtering of Laser Altimetry Data. International Archieves of Photogrammetry and Remote Sensing, Vol. 33, part B3/2, 935-942.

4. LiDAR - laser scanning method

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Soma Horváth – Danube-Ipoly National Park Directorate

LiDAR is an active-sensor 3D remote-sensing technique. It usually is conducted by plane producing a detailed laser scan of the surface and depths of a structure of a surveyed object (mainly forest). The modern equipment gathers a full reflection of each emitted laser pulse, making it possible to collect a detailed 3D model of its inner structure (e.g. density and height of second storey or shrub layer) of a forest stand between the top of the canopy layer (first reflection) and the ground layer (last reflection). Therefore the analysis of the 3D point cloud (the summary result of the part-reflections of the impulses) results not only in a digital elevation model (DEM – summary of the last reflections) and in a digital surface model (DSM – first reflections), and, as a difference between the two, a model of the height of the forest stand, but it also enables to evaluate many aspects of the richness of its internal structure. The latter has the most ecological significance, hence many attributes, which heavily influence the richness of biodiversity (e.g. microclimate, shade, light conditions, shelter, nesting place, etc.) are derivable from the inside conditions.

Hungarian experiences are limited regarding the adoption of LiDAR, although there are examples for use of the detailed DEM (water runoff modelling, cultural heritage mapping, mainly by national park directorates), and timber volume modelling (mainly state forestry corporations).

The results produced by the LiDAR survey in this project will be used to achieve the following goals:

1. Abiotic variables/objects/patterns:

- use of the good quality DEM for detecting geological anomalies, rock-formations and potential nesting places for birds (minimal required resolution of the impulses: 1-2/m2)
- detection of fortified settlements (minimal required resolution of the impulses >1-2/m2)
- collection of information regarding the land-use history: detection of remains of structures connected the historical forest use (railway track ballasts, coal-burning sites, cottages) (minimal required resolution of the impulses >4/m2)
- estimation of erosion and soil degradation caused by timber transport (minimal required resolution of the impulses >4/m2)

2. Planned uses for assessing/investigating ecological/biological attributes:

- detection of historical large scale disturbances (signs of root wads) (minimal required resolution of the impulses >6/m2)
- detection of vertical structure-richness of forest stands (minimal required resolution of the impulses >4/m2)
- detection and measurement of extreme tree heights (minimal required resolution of the impulses >2/m2)
- detection and measurement of canopy density (minimal required resolution of the impulses >1/m2)
- mapping the borders of big disturbances (e.g. ice breaks of the winter of 2014) (minimal required resolution of the impulses >1/m2)
- estimation of the volume of the laying coarse woody debris, if the density of the impulses allows it (minimal required resolution of the impulses >8/m2)
- prediction of areas containing high biodiversity relying on internal structure analyses (minimal required resolution of the impulses >4/m2)
- combination of the LiDAR data with aerial or satellite photographs to facilitate the habitat mapping

Besides the potential results of this survey, it can't be overlooked that remote sensing without on-site evaluation can result in misleading data. Hence, the currently used, intensive methods will be continuously used also in the future.

Further information on LiDAR:

Simonson, W.D., Allen, H.D. és Coomes, D.A. (2014). Application of airborne LiDAR for the assessment of animal species diversity. *Methods in Ecology and Evolution*.

https://besjournals.onlinelibrary.wiley.com/doi/full/10.1111/2041-210X.12219

Müller, J., és Brandl, R. (2009). Assessing biodiversity by remote sensing in mountainous terrain: The potential of LiDAR to predict forest beetle assemblages. *J. Appl. Ecol.*

https://besjournals.onlinelibrary.wiley.com/doi/10.1111/j.1365-2664.2009.01677.x

5. Case study on the usage of LiDAR for nature conservation and forestry management purposes

Use LiDAR to estimate the amount of wood briquettes produced during bush clearing

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5.1. Introduction

In the framework of the Environment and Energy Efficiency Operative Project (KEHOP) on 496 ha grassland around Fertő invasive alien tree species and shrub, elimination was carried out. During the project preparation, the area was divided into 538 different management units.

The main categories were:

- Homogeneous Russian olive, dense, impassable with elderlies
- Spread or grouped Russian olive occurrence
- Homogeneous common dogwood, impassable
- Mixed Russian olive-common dogwood shrub
- Green ash forest
- Young green ash forest
- Persian walnut
- Lines of native trees, with small groups or lines of invasive species

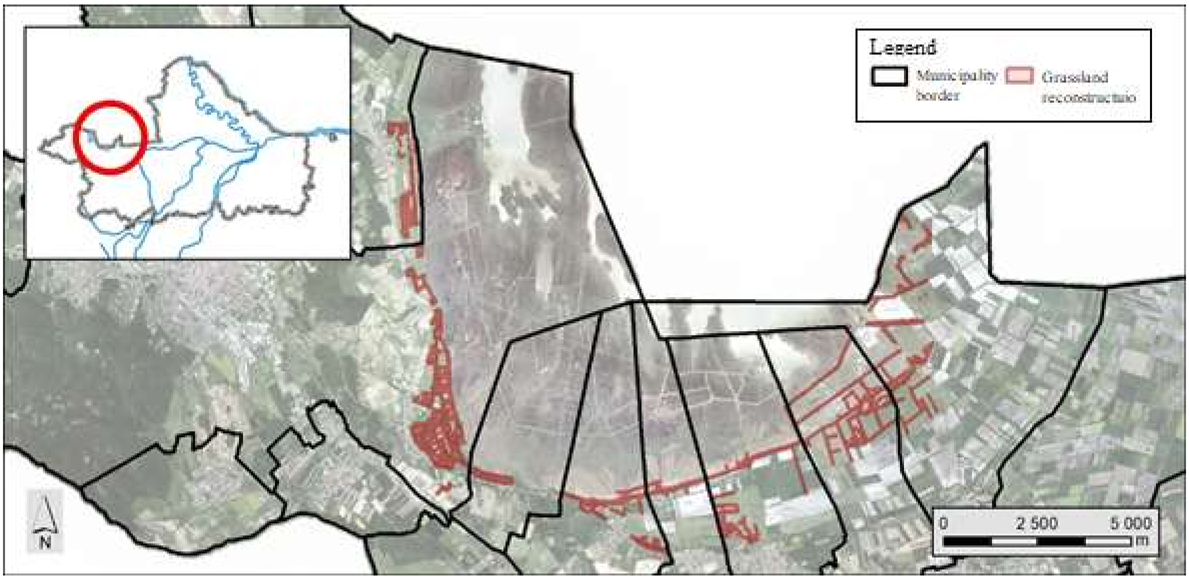

Figure 13: The review map of the grassland reconstruction in Fertő during the project

5.2. Description of the action

At the beginning of the project, it was evident, that from the felling shrub a significant amount of briquettes will arise, but the goal was to quantify the yield. The traditional forestry methods were found inadequate for this aim.

Figure 14: Some typical habitat types in the areas of intervention

5.3. Methods and materials

In 2017 the digital surface model (DSM) and digital terrain model (DTM) were prepared based on the LiDAR surveyfor almost the whole project site (only 5,8734 ha, 1,2% of the area, was not covered). From the two different models, the height of the vegetation (nDSM) and the volume is predictable quite precisely.

5.4. The affected area

While calculating the expected amount of briquettes, the study is focusing exclusively on those areas, which were considered in full coverage (the timber from areas, where only partial exploitation happened were not taken into account, such as the elimination of Russian olive trees from lines of native trees) and a significant amount of yield was expected (areas where only 1-2 spread tree or shrub individuals were cut). Thus, in total 121 subdivisions (130,3 ha) were involved in the evaluation. The expected amount of yield from the remaining area could be considered inconsequential.

5.5. Calculation of the volume of vegetation based on the LiDAR survey

Some details of the statistics of the nDSM can be seen on the following table. The volume, the 'growing space' can be found in the last column. The 121 subdivision's vegetation volume involved in the evaluation covers 5.603.432 m^3.:

FID	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	SUM
104	51256	51256	-0,028	19,15	19,18	8,88	3,13	454915,03
141	69401	69401	-0,25	18,85	19,09	4,81	3,64	334093,53
142	60649	60649	-0,14	15,81	15,96	5,03	2,86	305090,44
459	29057	29057	0	19,99	19,99	9,10	4,36	264483,06
145	33507	33507	-0,19	33,15	33,33	7,47	4,91	250301,61
429	48053	48053	-0,11	23,19	23,31	4,42	3,25	212430,89
520	23827	23827	-0,24	32,26	32,50	8,68	6,08	206892,42
9	35865	35865	-0,05	25,39	25,45	5,62	3,40	201575,32
77	20808	20808	-0,14	28,26	28,40	9,64	6,69	200503,89
497	25571	25571	-0,11	24,72	24,83	7,73	5,59	197640,66
400	25476	25476	-0,07	26,15	26,22	7,73	4,84	196974,78
110	17332	17332	1,29	19,53	18,24	11,04	2,93	191411,81
149	60089	60089	-0,03	29,60	29,62	3,07	1,76	184332,69
59	64642	64642	-0,18	14,18	14,36	2,66	2,45	172115,05
3	24932	24932	0,01	13,55	13,54	6,46	1,87	161145,28

Table1: Some details of the data series from LiDAR survey, with the volume result in the last column

5.6. Test cutting on sample plots

The sample plots with the most characteristic vegetation were appointed to allocate the effective amount of wooden vegetation, where the test cutting was carried out to compare the volume calculated from the LiDAR with the effective wood weight.

Type	Description	Area (m^2)	nDSM m^3	Cube content of stake (forest meter sters)	Briquettes (forest meter sters)	Multiplier Stake/ nDSM
1	Russian olive	2938	15363	633,75	140,40	0,0413
2	Russian olive groves	3207	9637	367,50	71,76	0,0381
3	Thick green ash	2741	24351	337,50	166,92	0,0139
4	Thick green ash	1893	11893	397,80	88,92	0,0334
5	Common dogwood	1216	2927	138,00	31,20	0,0471
6	Mixed Russian olive and common dogwood	1906	6819	216,00	46,80	0,0317

Table 2: Some details of the data series from LiDAR survey, deriving from nDSM

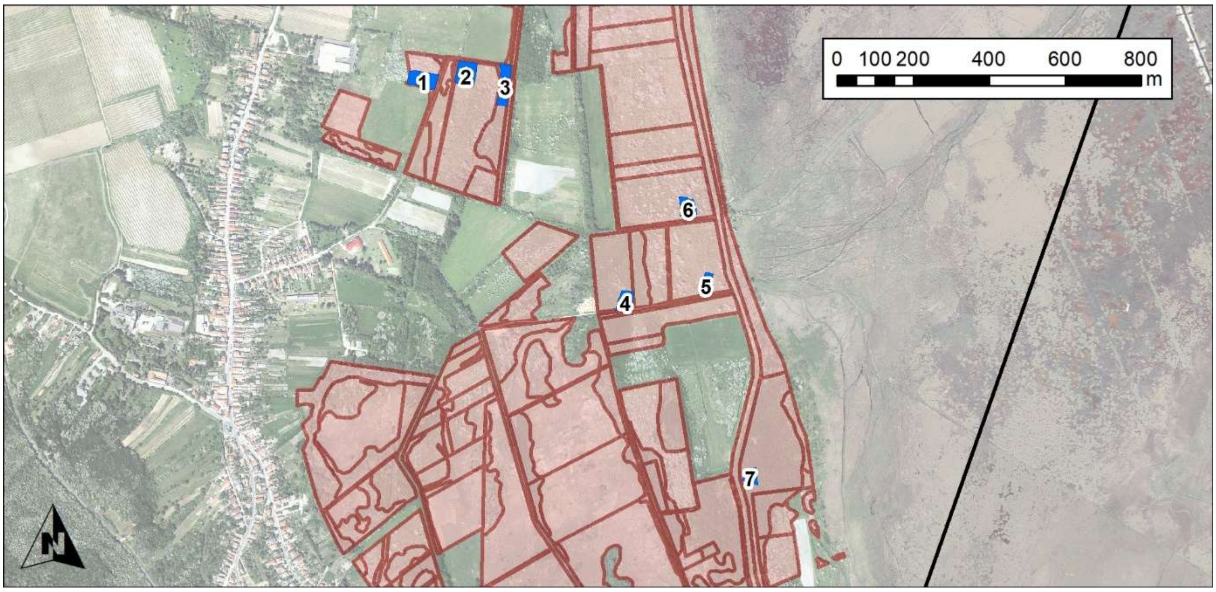

Figure 15: Distribution of the sample plots in Fertő sites

Figure 16: After cutting, rowing and shuffling to stakes, the cutting area was measured

From the 6 sample plots in a total of 2090,55 forest liquid measures were rowing, which made 93,76 t wet briquette, which means 58,084 atro t briquette (data from József Tóth). Based on the test cutting the multiplier can be determined, from which the sters of the rowable timber could be allocated for every type.

In the case of the chosen 121 subdivision based on the data mentioned above the rowed timber for the landfill was estimated for 213.228 forest sters meters (lose volume of the marketed stake).

5.7. Results

The method seemed primarily effective for the use in case of large, closed shrubs and for fast prediction of the expected timber production. In small areas, the method appeared inapplicable, because of the high expenses of LiDAR recording, as well as in case of low vegetation coverage due to the imprecision of the prediction.

The scarce number of sample plots and the characterization of the management units to sample plot types are a subject of uncertainty, which could be reduced with the increase of the number of sample plots. During the analysis solely the closed shrubs were assessed, which results in the underprediction of the expected timber yield for the total project site.

6. Forest state assessment methodology

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Based on Standovár et al, 2016.

6.1. Introduction

Traditionally timber production was the main usage of forests, but in the last decades, the social expectations on forests have changed. Therefore, next to the production function of the forests, other, often conflicting functions, appeared, including protective, biodiversity and ecosystem, social and cultural and economic functions.

To achieve conservation goals, one possible solution could be to separate the different functions with the designation of protective, recreational and economic forests for timber production. Thus, in many parts of the world, including Europe (where intensive land-use has a long history) landscape transition already reached the threshold, which made this approach feasible.

There is a need for reasonable strategic planning based on appropriate data for the integration of the different management goals, including a decision-making process that assures these needs on landscape-scale with monitoring to provide feedback on management activities to fulfill these goals. As a sufficient spatial resolution for planning, a description of the biological and commercial status and potential is needed.

Previously several data collecting systems were available, which focus mainly on tree species composition: age and size characteristics, volume as well as site conditions at the management unit and/or national levels (*Kangas & Maltamo, 2006*). Likewise, conservation bodies often rely on data collected in reserves and which are only relevant for conservation. For an integrated approach, which covers forest matrix and protected stands as well, both production and non-production objectives are required.

There are several categories of measurement methods, as forest inventories, forest management unit assessments, vegetation maps and biotic data. There is a large variety of definitions, protocols, sampling designs, and plot configurations. The European-wide harmonization of applicable methods was challenging, therefore a developing a harmonized technique to facilitate common reporting would solve the problem (*Chirici et al., 2011 and 2012*).

Detailed forest management planning is required for every forested area in some countries. In Hungary, forestry management plans are prepared for 10 years, based on field surveys comprising roughly 550.000 forest sub-compartments. The collected data on-site conditions, the composition of tree species as well as prescribed and already completed forest management activities are stored in the National Forestry Database (NFD) for each sub-compartment. Even though it is an essential tool for planning, biodiversity data are largely missing (Tobisch & Kottek, 2013).

For nature conservation management planning additional data on the distribution of protected and threatened species and/or habitats are needed. The units are usually either phytosociological units or more general habitat types (Evans, 2006; Molnár et al., 2007; Kent, 2012). On the other hand, forestry and habitat maps are only including typical values of a few variables, e.g., species composition of the tree or herb layers in sub-compartments of vegetation patches, regardless of the spatial variation within individual units. Despite that these data have a large spatial coverage, they lack the spatial resolution and thematic richness.

Structural data (e.g., vertical and horizontal structure of the tree canopy, amount, size and decay stage distribution of deadwood, type and amount of microhabitats) have been collected through different monitoring programs, e.g. on forest naturalness (*Bartha et al., 2006; Grabherr et al., 1998; McRoberts et al., 2012; Winter, 2012*), forest reserve programs (*Parvianen et al., 2000*) or specific conservation research focusing on habitat needs (e.g., deadwood, microhabitats) of certain forest specialist (*Ódor & van Hees, 2004; Ódor et al., 2006; Müller & Bütler, 2010; Larrieu et al., 2014; Gouix et al., 2015*). Similar data are collected within the framework of national monitoring programs of Natura 2000 habitats (*e.g., Louette et al., 2015*).

To determine the status of natural habitats is challenging, due to fact that the concept of Favourable Conservation Status is not unambiguously applied across Europe (*e.g., Mehtala and Vuorisalo 2007, Cantarello & Newton 2008, Brambilla et al. 2011*). The area covered by these monitoring systems is remarkably smaller than the area of semi-natural forests, which means that there is a lack of information on the actual stage of forest habitats of community interest.

For the proper forest management and conservation actions, higher data quality must be achieved both in terms of thematic richness and applicability over various spatial scales. The new data should serve the needs of both management and conservation aspects and need to serve as the basis for complex management action plans.

The aim of the forest state assessment methodology is to provide and integrate the necessary supplementary information to existing forestry and vegetation data and serves as a stand-alone tool for the assessment of the conservation status of our forest at a fine spatial scale. Hereinafter, the developed methodology will be presented.

6.2. Methods

General criteria and sampling scheme

The forest state assessment protocol was developed within the framework of the project “Multi-purpose assessment serving forest biodiversity conservation in the Carpathian region of Hungary”. The main aim of the project was to collect complementation data on forestry and conservation databases and to integrate all to emphasize the conservation of habitats. The work has been carried out in the Hungarian Carpathians, in the Börzsöny, Mátra and Aggtelek Mountains (Hungarian Carpathians).

The main goal of the forest state assessment was to collect structural and compositional data that were missing and that could be used by forest managers and conservation bodies (national park directorates) for strategic as well as daily planning of forestry and conservation activities. The method supports the analysis of forest naturalness and could help to find potential hotspots of biodiversity.

The methods had to fulfill the following criteria:

1. Simple and fast measurements or estimates without the need for special equipment,
2. Reproducible methods to allow for many field workers,
3. Data comparable to existing databases,
4. Appropriate data for supporting forest management planning and conservation planning,
5. Production of thematic maps at the scale of 1:10.000 for direct use in conservation management plans and production of traditional maps such as habitat type maps.

Systematic point sampling was used in order to achieve spatially explicit data, which serve as a base of maps with several distinct thematic contents. The size of circular plots was chosen according to the national forest inventories. Other investigations use 500 m² circular plots (*Tomppo et al., 2011*).

Variable selection and choice of measurement methods

Potential variables were selected from existing forest inventories (*Winter et al., 2008; Kolozs, 2009; Chirici et al., 2011; Tomppo et al., 2011*), forest naturalness surveys (*Bartha et al., 2006; Paillet et al., 2008; McRoberts et al., 2012*), forest reserve programs (*Hochbichler et al., 2000; Christensen et al., 2005*), Natura 2000 habitat monitoring (*Cantarello & Newton, 2008; Hernando et al., 2010; Velázquez et al., 2010*), specific conservation projects (*Kirby et al., 1998; McElhinny et al., 2005; Liira & Sepp, 2009*) and international projects e.g., ForestBIOTA (*Fischer et al., 2009*). Based on that a list of considered variables was put together.

The novel methodology and data collection system

The survey was based on a systematic grid of field points. The density of the grid is two points per hectare. The densities of three different and joint grid were established to use for stands with varying structural complexity. For the most heterogeneous stands a dense grid of 50 m × 50 m was laid out. By selecting every second or fourth point in more homogeneous stands, a network of sampling plots in every 70 m or 100 m was set up.

Three distinct sampling units were used. Most data are collected for the 500 m² circular plot, while shrub and regeneration data are gathered in the 30 m² subplots. Between the plots, variables occurring at coarse spatial scales and attributes carrying particular interest, even if found only outside the plots, were recorded on the route.

Table 1. Variables collected in the multi-purpose forest state survey with brief descriptions of the most important attributes. (Sandovár et al., 2016).

Sampling unit	Variable group	Variable	Definition and/or codomain
ROUTE		Site-related microhabitats	rockwall, spring, etc.
		Natural disturbance	recent and large disturbances
		Disturbance type	broken tree, fallen stem, fire, biotic agents
		Large trees	outstanding live or dead trees
		Invasive tree species	any form of invasive tree species
		Animal traces and indicator species	bough bird nest, woodpecker trace, N2000 species
PLOT	General description	Main category	mature, young, regenerating stand
		Physiognomy in mature stand	sprout stems, merging canopy and shrub layers, pasture land use
	Features of regenerating stands	Regeneration cover in regenerating stand	
		Description of the regenerating stand	
		Weed and shrub species in regenerating stand	
	Canopy composition and structure	Canopy closure	percentage value based on visual estimation
		Tree species composition	record every occurring tree species by estimating cover in broad categories (0-5%, 6-20%, 21-50%, 51-100%) in diameter classes (Ø: 0-8, 9-20, 21-35, 36-50, >50 cm) per species
		Bark stripping	fresh damages on at least 5% of stems
		Anthropogenic stem damage	fresh damages on at least 5% of stems
	Standing deadwood	Number of standing dead trees (> 2.5 m)	number of stems in diameter classes (Ø: 9-20, 21-50, >50 cm)
		Decay stage of standing dead tree(s)	fresh, mixed, decayed
		Standing dead trees species	identified species
		Number of snags (< 2.5 m)	number of stems in diameter classes (Ø: 9-20, 21-50, >50 cm)
	Lying deadwood	Quantity of lying deadwood	visual estimation of FWD (Ø: 0-8 cm) and CWD (Ø: 8- cm) quantity and diameter distribution in 9 categories
		Decay stage of CWD	fresh, mixed, decayed
		CWD species	identified species
	Herbs	Herb cover	percentage value based on visual estimation
		Dominant herb species	herbs with over 20% relative cover (max. 3 species)
		Site indicator herbs	moisture and acidity indication (max. 3 species)
		Adventive herbs	
		Herbs indicating disturbance	relative cover (ordinal scale)
	Microhabitats and disturbances	Tree-related microhabitats	rootplate, stump, bird hole, Polypores, etc.
		Soil disturbance	severity of soil disturbance (ordinal scale)
		Soil disturbance type	wheel, skidding, game
		Rock cover	rock cover (ordinal scale)
		Debris size	rubble (small, medium, large), bedrock
		Adventive species present	adventive regeneration and shrub species present outside the subplot
SUBPLOT	Shrubs	Shrub cover	percentage value based on visual estimation (ordinal scale)
		Dominant shrub species	shrubs with over 20% relative cover (max. 3 species)
		Site indicator shrubs	moisture indication
	Regeneration	Cover of high and low regeneration	percentage value based on visual estimation above and below 0.5 m (ordinal scale)
		Regeneration tree species	dominant and non-dominant species
		Browsing	unbrowsed, slightly, heavily browsed, bonsai-like
		Proportion of sprouts	
	Documentation	GPS coordinates	coordinates of plot center
		Photographs	photo documentation towards N,W,S,E,upward and plot center
		Comment	comment regarding any variable

Table 3: Variables collected in the multi-purpose forest state survey

The most important variable groups include canopy composition and structure, deadwood, herb species, shrubs, regeneration, microhabitats and game pressure. Data collection on canopy composition aimed at describing the cover of every appearing tree species and at detecting rare species.

Special data were collected, which were missing from the National Forestry Database e.g. standing trees, the amount of lying dead wood, data on herbaceous species focusing on habitat indication and the presence of selected tree microhabitats.

At each sampling plot, six photographs were taken for documentation and averaged longitude and latitude coordinates were collected.

For the purpose of the forest state survey, a digital data collection system was developed. The empty forms are downloaded safely for fieldwork in predefined packages containing approx. 30 grid points using the ForestDataCollect (FDC) app.

The training of field crew was crucial for guaranteeing high-quality data, therefore all members took part in a series of indoor and outdoor training lessons and had to pass exams. Quality assurance is also implemented during fieldwork, data import and data analysis.

6.3. Application

The survey was designed to enable the collection of large numbers of samples.

One of the most important applications is that distribution maps can be drawn for tree species that can serve as hosts for specialist species. During the first field season of our survey, more than 20.000 new records on the occurrence of 36 native tree species were gathered in the 11.194 sampling points that contained canopy trees. During the survey, new tree species were recorded in 97% of the sampled forest sub-compartments.

The number of tree species varied between 1 and 12 with an average of about 4 species/plot. The diameter distribution of trees within plots seemed rather diverse.

Species richness and diameter class diversity (DCD) alone are not adequate alone to use to estimate naturalness, as these variables are not sensitive to the presence of alien species in the sampled forests. Almost 8% of the plots contained adventive species outside plantations. Most of the occurrences were Robinia pseudoacacia L. individuals (633), followed by Quercus rubra L. (88) and Juglans regia L. (80). Data on alien species can be used during management planning.

Tree-related microhabitats can serve as indicators of the potential occurrence of forest specialist species such as xylophagous insects, but the presence or absence within one plot does not convey enough information on the probability of occurrence.

6.4. Conclusion

The aim of the method was to develop a tool that provides reliable and relevant data for supporting the strategic planning of both forest management and nature conservation. The method needs relatively low manpower input per plot and uses solid estimator methods combined with user-friendly direct database recording.

After the training, it emerged that the staff does not require special background knowledge. The chosen technical solutions were available, functional and reliable.

Preparation of relevant (both from conservation and forestry viewpoints) thematic maps based on individual attributes was manageable. The method seemed a much more efficient tool in management planning than traditional polygon-based maps using single or just a few attributes for classification. Attributes can also be freely combined to create specific scales of forest quality and rank plots based on various aspects. Similarly, the high potential biodiversity of specific organism groups can also be defined using relevant combinations of the recorded variables. By aggregating data. Landscape-scale considerations can be taken into account as well.

In addition to supporting management planning, our results could be applied for monitoring the effects of habitat management, for assessing the conservation status of Natura 2000 habitats, or for supporting habitat suitability assessments.

It is equally important that all actors in the respective fields are sufficiently informed and ready to collaborate using a common information platform.

More information on the method:

https://akademiai.com/doi/suppl/10.1556/168.2016.17.2.5

https://www.dunaipoly.hu/uploads/2017-04/20170419104310-rosalia-9-tomoritett-nu85zz4y.pdf

The detailed protocol of the multi-purpose forest state assessment:

https://akademiai.com/doi/suppl/10.1556/168.2016.17.2.5/suppl_file/168.2016.17.2.5_esm.pdf

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7. Assuring quality in grassland management with a goal-oriented database

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7.1. State of the art

There are 10.000 ha, likely 100.000 ha grassland under the asset management of national park directorates in Hungary. The grasslands under the Danube-Ipoly National Park's asset management involve really diverse environmental habitats. The grasslands are impacted by many varied treatments and have many impacts. The human impact has the main role in the creation of these habitats.

However, there is a lack of real, systematic, analysable information about the events happening in the area.

The Danube-Ipoly National Park Directorate does not have enough accurate information on the grassland management, the development of the grasslands and their state (including the tendency of the wildlife trends).

The exact grassland management actions are unknown to the general public (within the National Park Directorate), except for the lessees, the assigned rangers and the region leader rangers. Besides, the management actions are typically not documented on paper.

There is a lack of (available) information regarding the tendency of wildlife trends in the area, as well as whether the grassland management actions are correct or not. There is an absence of strategic planning at the institutional level and the regarding leading instructions for the concrete area, even though the management actions seem obviously incorrect or suboptimal, caused only by extant circumstances.

These reasons make the evaluation, monitoring, review, controlling, documentation, influence and harmonization of the grassland management's advisedness really hard. It also strengthens the harmonization of nature conservation's aspect and economic aspect as well as its usage for intersectoral lobbying etc.

In practice, usually, it depends on the recollection of people, to bring up the management history of the different sites. This imponderable and subjectivity baulk the experience and knowledge gaining process too (development of collective knowledge on proper grassland management actions). In the case of personal fluctuation of farmers or rangers, the new ranger should start to learn about the area and its past from the beginning.

Planning and documentation should not become conventional and unbending. The keywords are management guidelines. A positive shift from the predetermination, regular checking yet still obscure, undocumented, unrecorded old systems without feedback is needed.

It is important to mention, that even the documented (well-thought-out, agreed upon, written) nature conservation goals are missing. These should refer to what is expected in a concrete area, to what the main nature conservation goals are and to which the criteria of the evaluation the wildlife trends are.

Object of the goal-oriented database:

- To make the area management more effective in terms of wildlife conservation.
- To help the work of rangers and to assure the quality to improve grassland management.
- To document the treatments performed: the NP Directorate and rangers should have at their disposal accurate and operative, documented local information, which is regularly updated with joint information on wildlife state (based on monitoring methods).
- To define grassland management treatments in terms of efficiency.
- To give feedback according to the local wildlife trends:
  - recognize in time trends which are showing an adverse development
  - explore the reasons
  - propose a change in the management (assuring the quality)
- The data collection should be human capacity wise, realistic and sustainable.

The question is (for the rangers and the NP Directorate): what kind of information is missing the most? It should be analysed, which information would be needed to improve the work of the rangers. What kind of operational intervention will be possible? Are the results of these actions and interventions proportionate to the time and energy invested in data collection?

The monitoring of the state transition and recorded management actions should be combined in the database level, or at least attention should be paid to avoid lack of information in between.

Moreover, the differentiation of the several ranger's districts has to be taken into consideration.

A well-functioning quality assurance system would ease the information gap between the rangers and the NP Directorate and would improve the decision making as well as strategic planning mechanisms based on objective data.

7.2. Materials and methods

How will the data, deriving from the information collection, be used?

- To document our actions: to be aware - what is happening in our area.
- To evaluate the effect of our actions: is it good, what we are doing?
- To plan our actions: what should we do the same way, what should we do differently?
- To communicate it to the society and to different sectors: for lobbying, for sectoral strategic planning.
- To improve the transparency of nature conservation events, serving as the base of the rangers' work and for professional negotiations within the sector.

The requirements of the system:

- Operability (sustainability).

- Practical usability.
- Possibility of data evaluation.
- Ability to document the summarized area of thousands of ha.
- Ability to record facts on a wider scale, ability to measure quantified data on field / data scan.
- Be estimated with a high degree of certainty / ability to record monitoring data.
- Possibility to store data and organize it as an analysable database.
- It can be taught to the participants of the data collection.
- We are in an iterative process, and keep revising: What kind of data collection, storage, or maybe communication forms would be adequate? What should be the database and structure (keeping in mind the HR capacity, sustainability, the possibility of future expansion, ability to retrieve and connectivity)? How can it improve the rangers' work and make the grassland management more effective? What do the rangers need for the successful negotiations with the lessees? How can it improve management-register and monitoring?
- To justify data collection (what kind of data should be collected) is an optimization procedure. The solution is between no data and every data, the more operative is the more usable.

7.3. The actual testing of DINPD – the system being introduced: „Goal-oriented database"

The DINPD's quality assurance system (goal-oriented database) is currently being tested on the Gerje-Perje Landscape Protection Area. The collected data will be used in the administration process of protected status declaration too.

The „goal-oriented database" system's main attributes, the structure of the data collection:

1. Identification of the management block (The management blocks should be marked on the geospatial coverages, which are the territorial base unit of the data collection. Usually, it corresponds to the land registry references and the territorial units according to lease contracts).

2. Background data:

- land use
- Territorial dimension (ha)
- Codes from description and determination of Hungarian habitat's vegetation (ÁNÉR) with territorial rates (derived from habitat maps)
- Values of naturalness with territorial rates (derived from habitat maps)
- The source of the habitat map: name of the maker, year
- Protection status

- Owner
- Land user (Currently we are working only with the grasslands owned by the NPD, which include own asset management and leased land).

3. Nature conservation goals and adequate management planning:

3.1.: Elemental (long-term) nature conservation goal:

- Planning:
  - Conceptual management tasks
  - Realistic, short term management tasks for the next season, which are implementing the first and second nature conservation goals, reflecting on the problems. propose a change in the management (assuring the quality.
  - Communication with the lessees (e.g. better implementation of X point of the contract).
- Feedback:
  - The compliance of the appointed management appropriation
  - The state of the area in terms of the elemental nature conservation goal (according to the subjective judgment of the ranger) improving/declining/stagnating

3.2. (Long-term) nature conservation goal 2. (Without further explanation, in bullet points)

3.3. (Long-term) nature conservation goal 3.

4. Proposal for monitoring (Are we proposing for detailed biomonitoring, or is there an ongoing organised-regular nature conservational data collection in the management block?

5. State of the water: above the ground "shining water surface"

- Highest water coverage level during the year for the whole block (%)
- Date of the highest water coverage (month)

6. Economic goals and possibilities

- Are we aware of any kind of conflict between the economic and natural conservation interests/goals

  Yes/No
- The management cannot be implemented in the economic base, but t requires a separate nature conservation action.

  Yes/No

7. Problems, threats (for the state of habitat/species)

- Is there a tendency to getting nondescript or degradation? (Due to under or over usage, environmental or other reasons.) . If yes, a longer description is needed (possible reasons, since when at what rate).
- The area is nondescript („O” category in ÁNÉR, and/or bad state).
- Is there a shrub outcome/distribution?
- Is there a distribution f perennial invasive species?
- Is there a concern of ploughing? (e.g. in the edges, or cross-ploughing or total ploughing is realistic in the close future?)
- Is there a known decline within the population of a protected species? (Not just an objective study, but a professional prediction, anticipation could be mentioned as well.)
- Were there any unpredictable events? (fire, wild boar disturbance, etc.).
- Other notes

8. Documentation of the treatments (in the concrete year)

8.1. Implemented water retention (or other water regulation)

- Did happen (or is happening currently) a relevant water regulation treatment? No/Yes. Direct (the management block's area is the venue of the water regulation object) or Indirect(the management block's area is not the venue of the water regulation object).
- Method of water retention: 1) Type: water retention object (in the channel of the watercourse) / by facilitation. 2) Appliance: flood gate / sandbag / other

8.2. Implemented grazing:

- Start of grazing: (which week)
- End of grazing: (which week)
- Species of the grazer
- Animal unit/ha
- Method of grazing e.g. grazed freely (guided by the shepherd) / electric fencing on large area / in sections
- Other notes on the grazing method

8.3. Implemented second-growth hay grazing:

(same as point 8.2)

8.4. Implemented mowing

- Type of the mower (drum, disc, other)

- Length of the mower (blade) (the length of the mowed bend at once)
- Date (which week)
- The bends to leave are the non-mowable part (where mowing can not be implemented), which area is not accessible (by machinery) as getting over the creation of the bends to leave.

  Yes/No
- Size of the hiding bends (latitude of bends cm or patches in m2)
- Are the hiding bends in the same area as last year? (Yes/NO)
- Was there any change in the spatial area of the leaving bends compare to the last year? (Yes/No)

8.5. Implemented clearing mowing

- Date (which week?)
- Method (stalk crushing, mowing, other)

8.6. Targeted elimination of invasive species

- Species
- Date (season)
- Methods (mechanic, usage of chemicals, other)

8.7. Shrub cutting / shrub removal (if not invasive)

- Appliance (stalk crusher, machinery hand sawing, chemical, other)
- Date (season)
- Other notes on shrub removal

8.8. Reed harvest

- Date (season)
- Appliance

8.9. Sodding / grass introduction

- The vegetation of the swarded sites (directly before swording)
- Date of the last mowing (month)
- Method of swarding (e.g. Lucerne seeding, regarding only spontaneous processes, helping the spontaneous processes with mowing (and grazing), mixes seeds seeding. The composition and origination area of the propagulum sources (reproductive material), hay coverage, soil preparation before seeding).

8.10. Other treatment

The filling of the attributes – according to the experiences so far – requires 20 minutes per management blocks (for 2 people), for at least on the first time. In the following years, the decrease of time-related costs is expected.

The database (in place of Excell) will be more modern(smoother a wider usage) in the form of data sheets (in the aspects of data entry, usability and analysable).

The feedback of the rangers' department on the "gal-oriented database" so far:":

- Gap filler to the documentation and on planning
- Awareness and perceptivity raising. Guideline and motive for intersectoral negotiations, professional consultations.
- Can serve potentially as a base of institutional level decision making and strategic planning (leading instructions)
- Can serve potentially as a base of the modification/renunciation of lease contracts.

The database can be used by the co-workers of the NPD:

- The tendencies of grasslands could be monitored: getting nondescript, degradation, or under the threat of cessation from other reasons.
- Background data for the nature conservation management plans.
- Statistics and reports to constructed.
- By negotiations with other sectors it could serve as a base, it is a reliable information source.
- The base for monitoring the tendencies in a large-scale area. It can be used for statistic and concrete local levels as well.
- The main problems can be found, as well as the areas needing special attention, the combination of different problems can be visible in the geographical information system, etc.

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