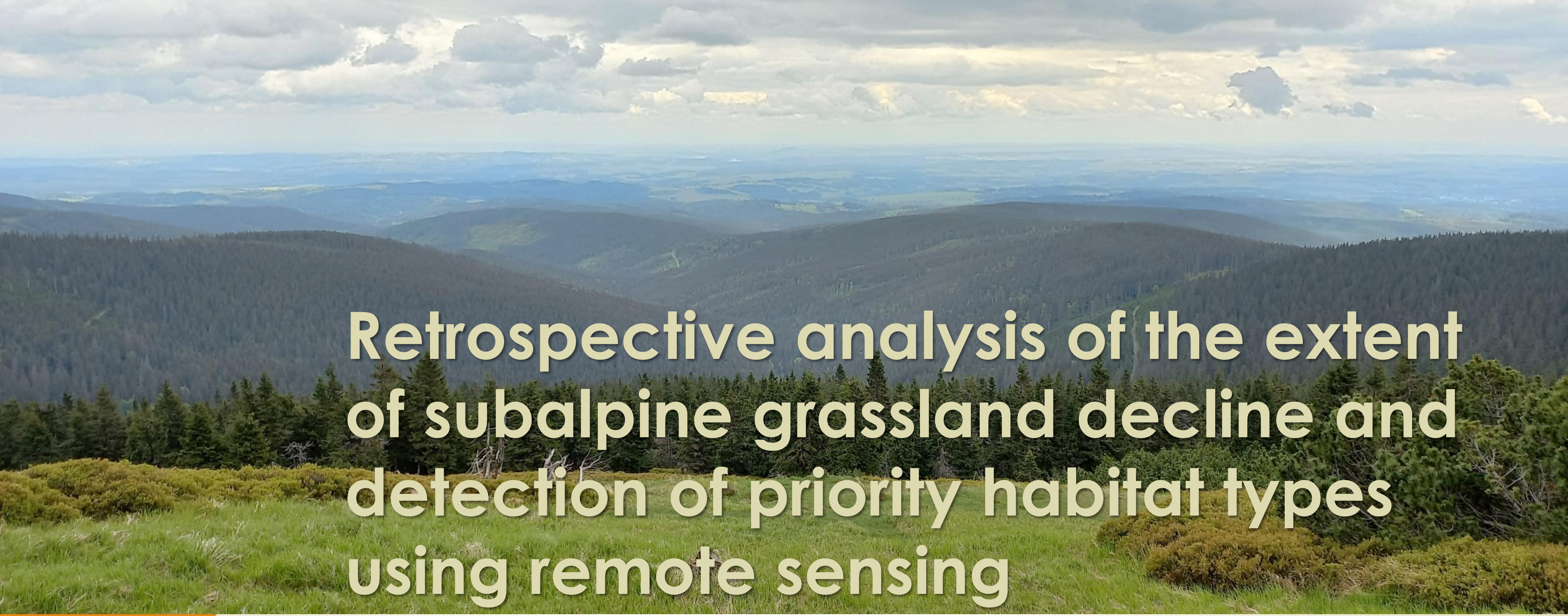

Retrospective analysis of the extent of subalpine grassland decline and detection of priority habitat types using remote sensing

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The Silva Tarouca Research Institute for Landscape and Ornamental Gardening (RILOG)

Výzkumný ústav Silva Taroucy pro krajinu a okrasné zahradnictví, v.v.i. (VUKOZ)

Project TAČR – Environment for life (SS03010065): Causes of decline and a system of effective restoration of priority habitat types of subalpine grasslands

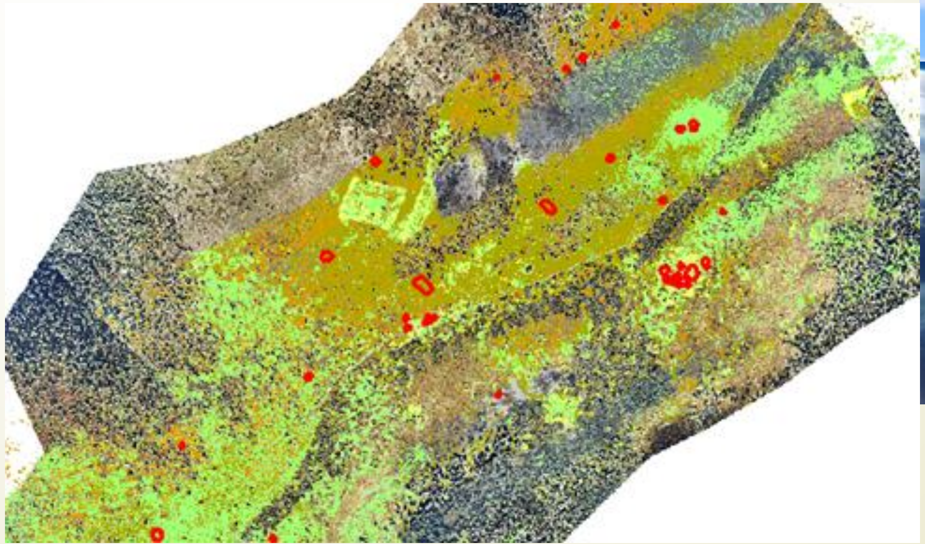
Participation of Dept. for Landscape Ecology RILOG is intended to achieve two project goals:

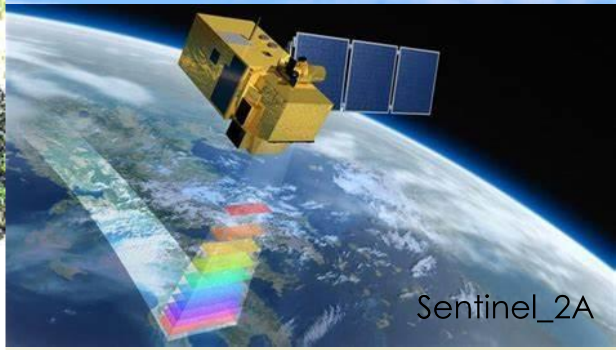
- To detect the areas of dying grassland at Jeseniky mountain range using remote sensing techniques; to assign its extent in modern times, as well as in the past decade
- To create an up-to-date high-resolution map of priority vegetation types at Jeseniky subalpine belt

1. Dying grassland detection

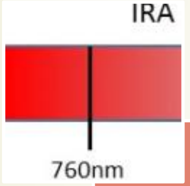
- Main approach: calculating **spectral indices** for non-photosynthetic biomass detection
- Input imagery data:
  - extra-fine resolution airborne imagery for September 2021 (6-band multispectral camera carried by a Trinity F90 drone (RILOG) (res. 0.1 m), CASI/SASI suite of hyperspectral sensors carried by Flying Laboratory of Imaging Systems (CzechGlobe) (res. 1.25 m);
  - free-of-charge multispectral satellite imagery (Sentinel-2, Landsat) for 2011 – 2020 (res. 10-30 m)
- Input ground data: 37 plots in total = 981,303 pixel values for 5 vegetation types:

1. bare soil (rock slides & trampled soil),
2. *Avenella flexuosa* dom. (Grass_1),
3. *Nardus stricta* dom. (Grass_2),
4. *Luzula luzuloides* dom. (Grass_3),
5. **dead grassland**





Spectral indices for non-photosynthetic biomass



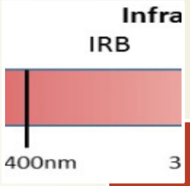
RED-EDGE-based

- LCI = (NIR – RedEdge) / (NIR + Red)
- NDRE = (NIR – RedEdge) / (NIR + RedEdge)
- Etc…

show absence of chlorophyll (“yellowness”)

COMBINED

- DFI = 100 x (1 – SWIR2/SWIR1) x Red/NIR
- NDV7 = (NIR-SWIR2)/(NIR+SWIR2)
- NDI = (NIR-SWIR1)/(NIR+SWIR1)
- NDSVI = (SWIR1-Red)/(SWIR1+Red)
- Etc…



SWIR-based

- NDTI = (SWIR1 – SWIR2) / (SWIR1 + SWIR2)
- STI = SWIR1/SWIR2
- SWIR32= SWIR2/SWIR1
- Etc…

show absence of water (“dryness”)

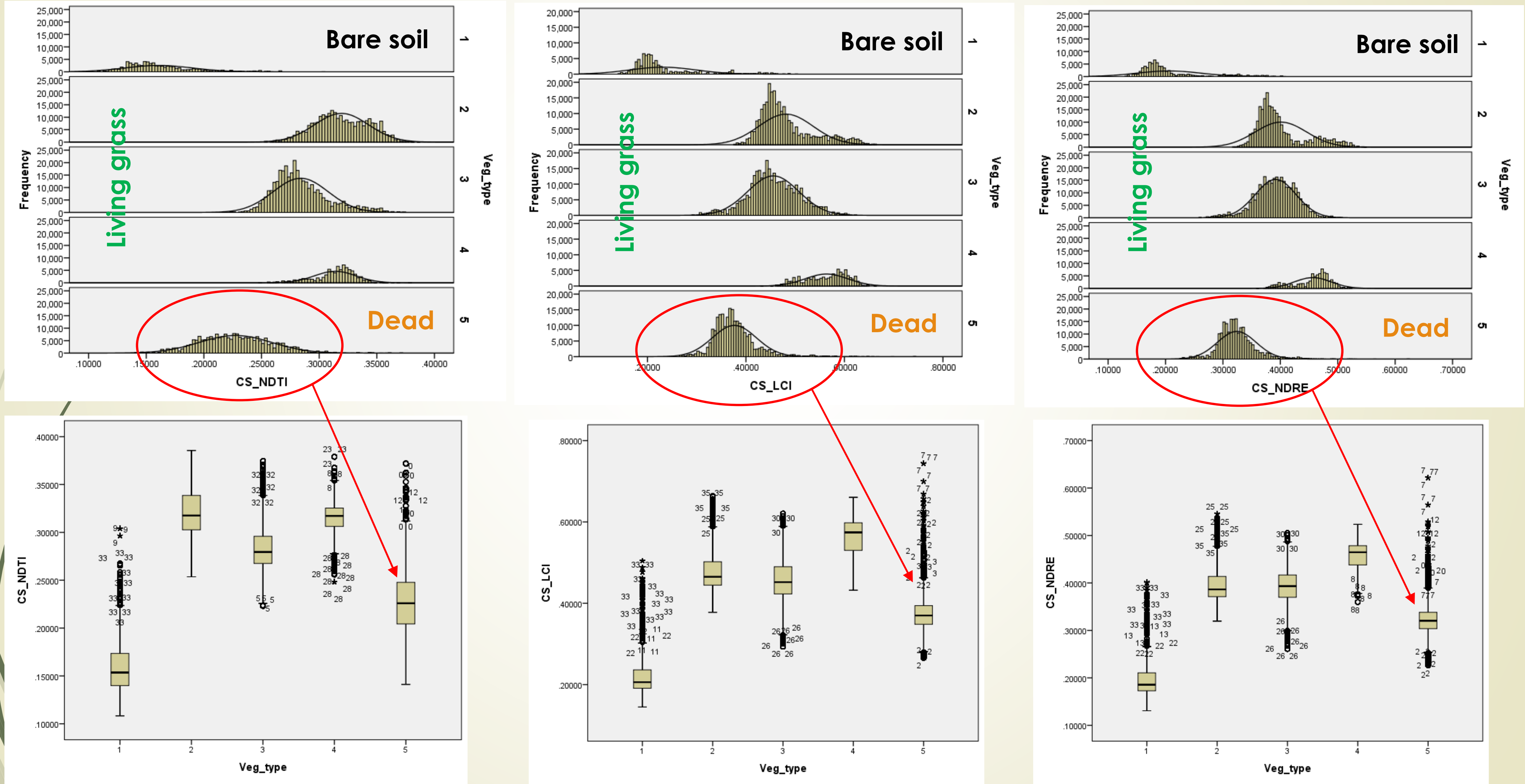
Application depends on sensor’s band composition. Success in using of one or another index is also site-dependent

NDTI, LCI & NDRE (the best) – statistics

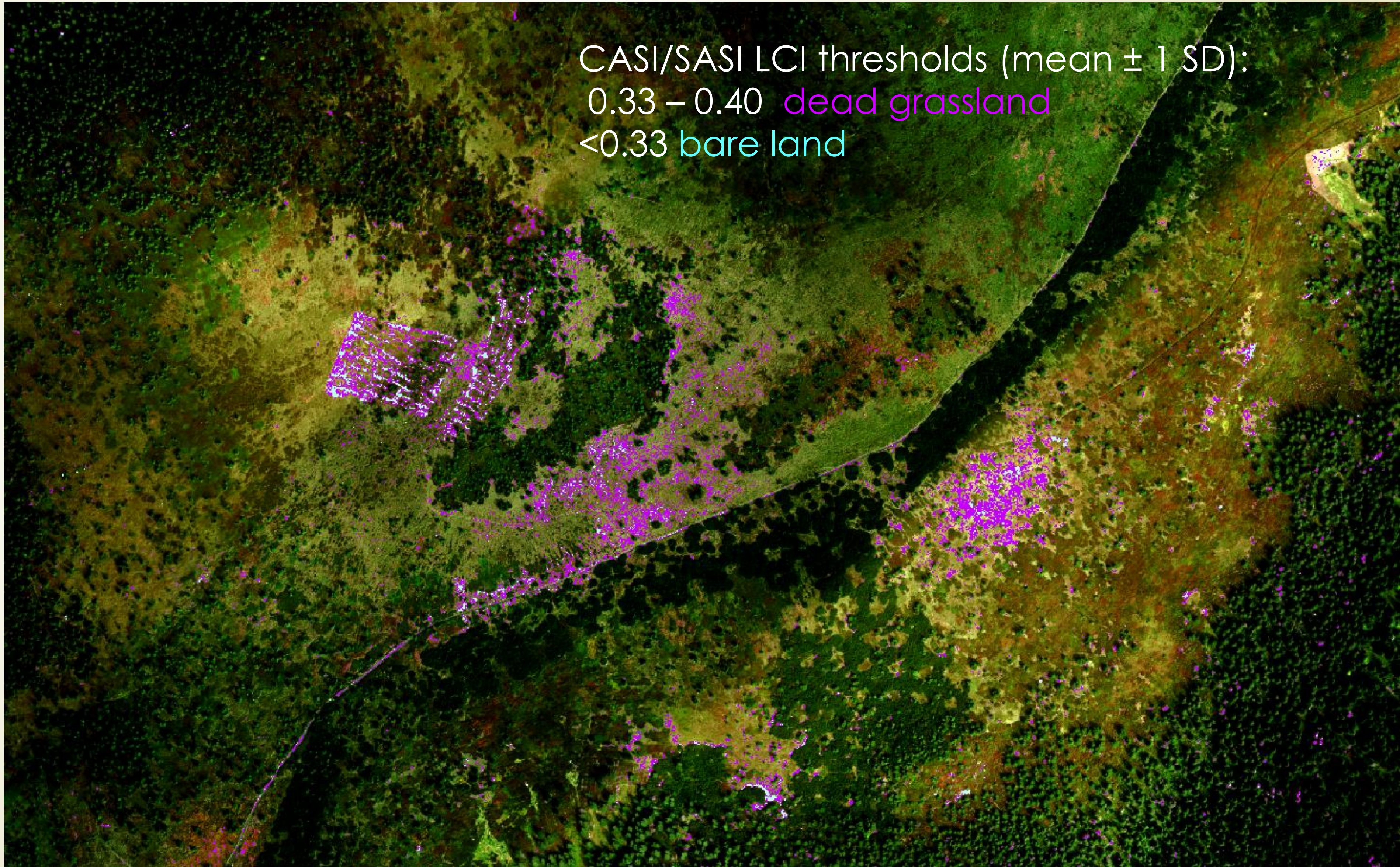
NDTI = (SWIR1 – SWIR2) / (SWIR1 + SWIR2)
LCI = (NIR – RedEdge) / (NIR + Red)
NDRE = (NIR – RedEdge) / (NIR + RedEdge)

VEGETATION TYPES

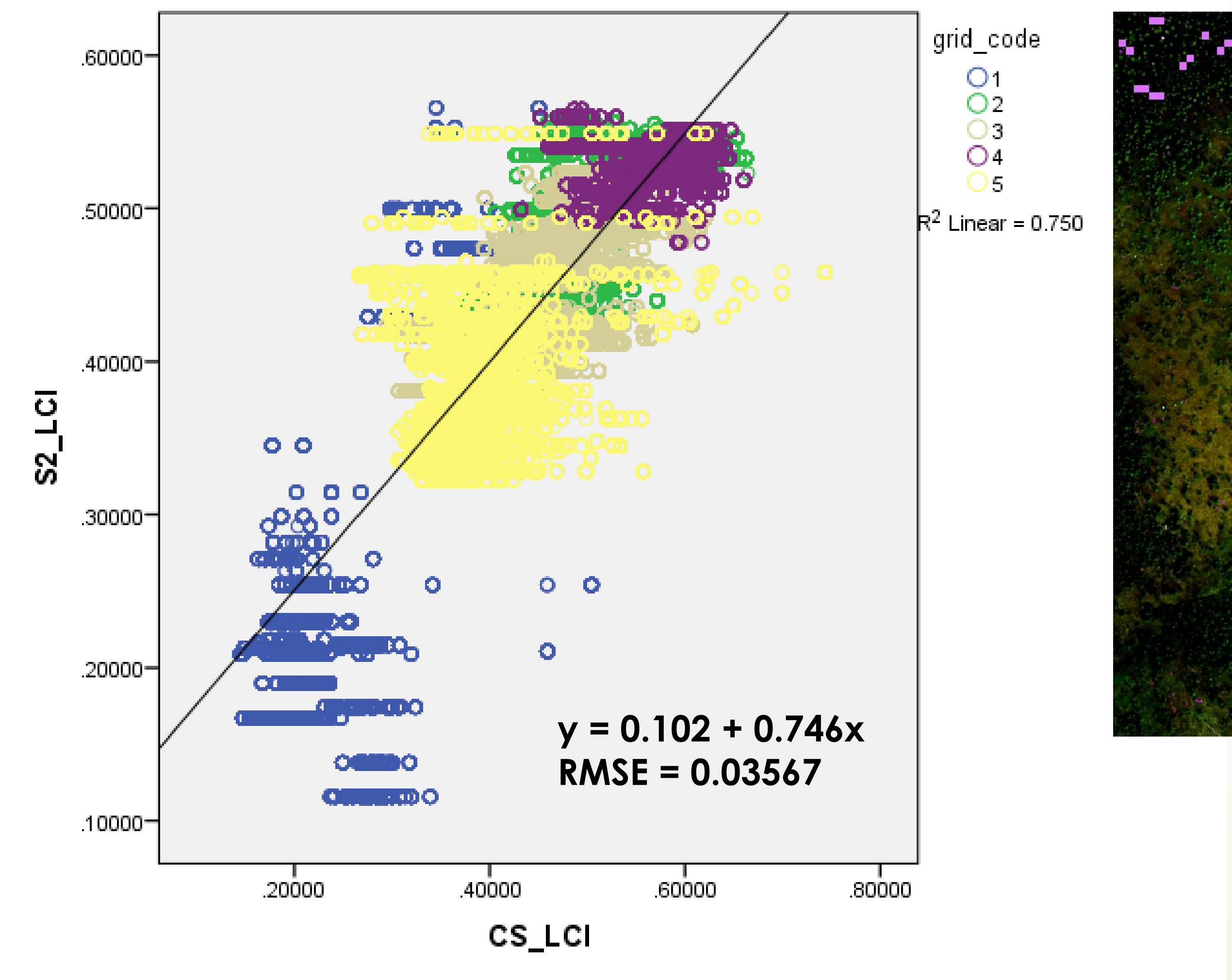
1. bare soil (rock slides & trampled soil),
2. *Avenella flexuosa* dom. (Grass_1),
3. *Nardus stricta* dom. (Grass_2),
4. *Luzula luzuloides* dom. (Grass_3),
5. dead grassland

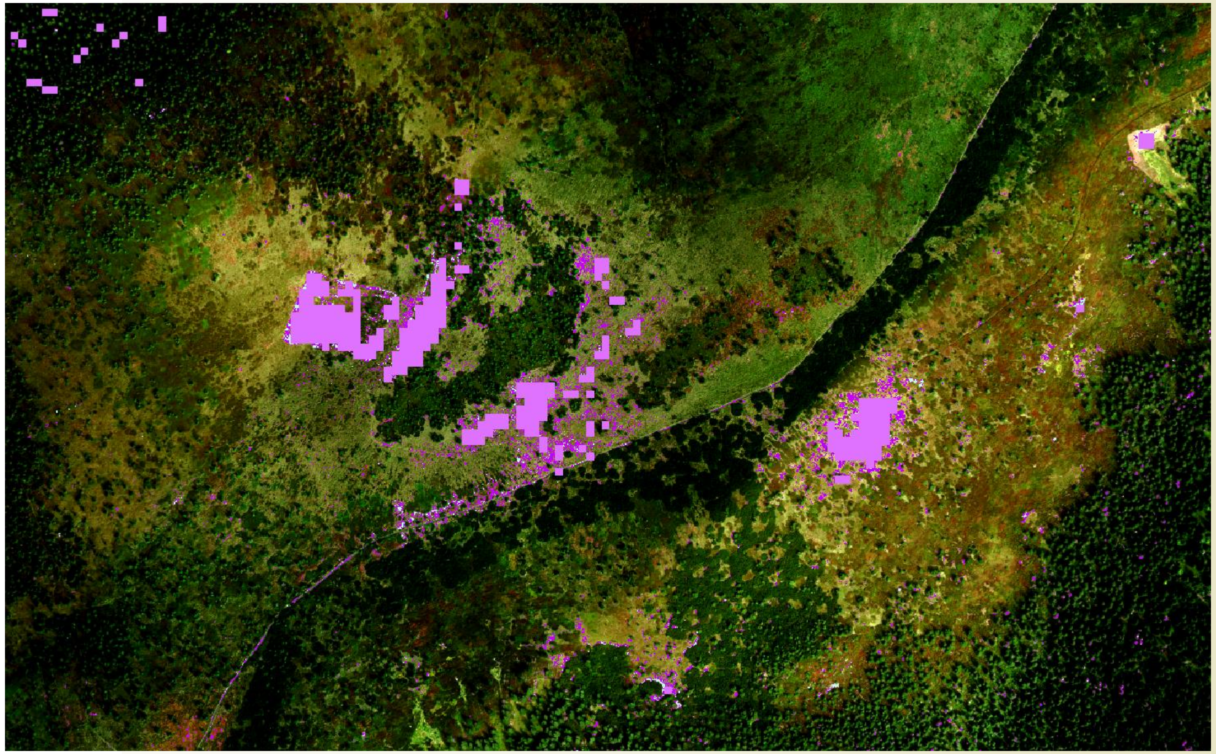


2021 dead grassland (CASI/SASI-based LCI)



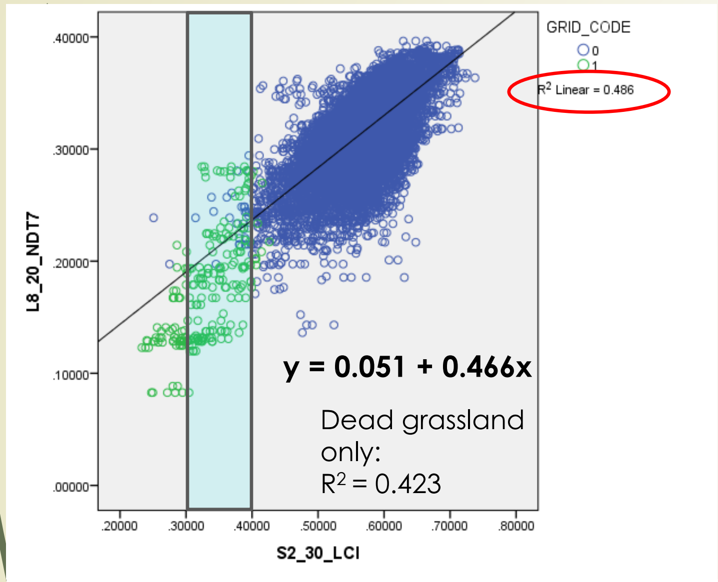
YEARS 2015 – 2021: **Sentinel-2** imagery (res. 10m)

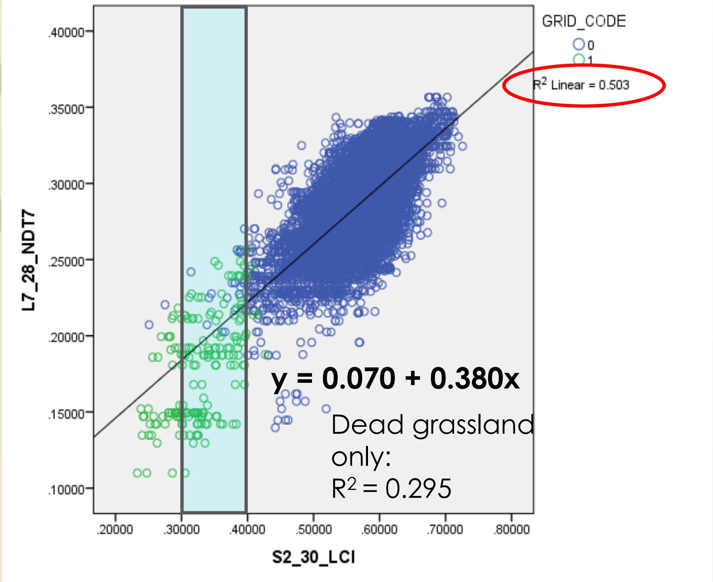




SENTINEL-2 LCI thresholds:
0.349 - 0.416 dead grassland
<0.349 bare land

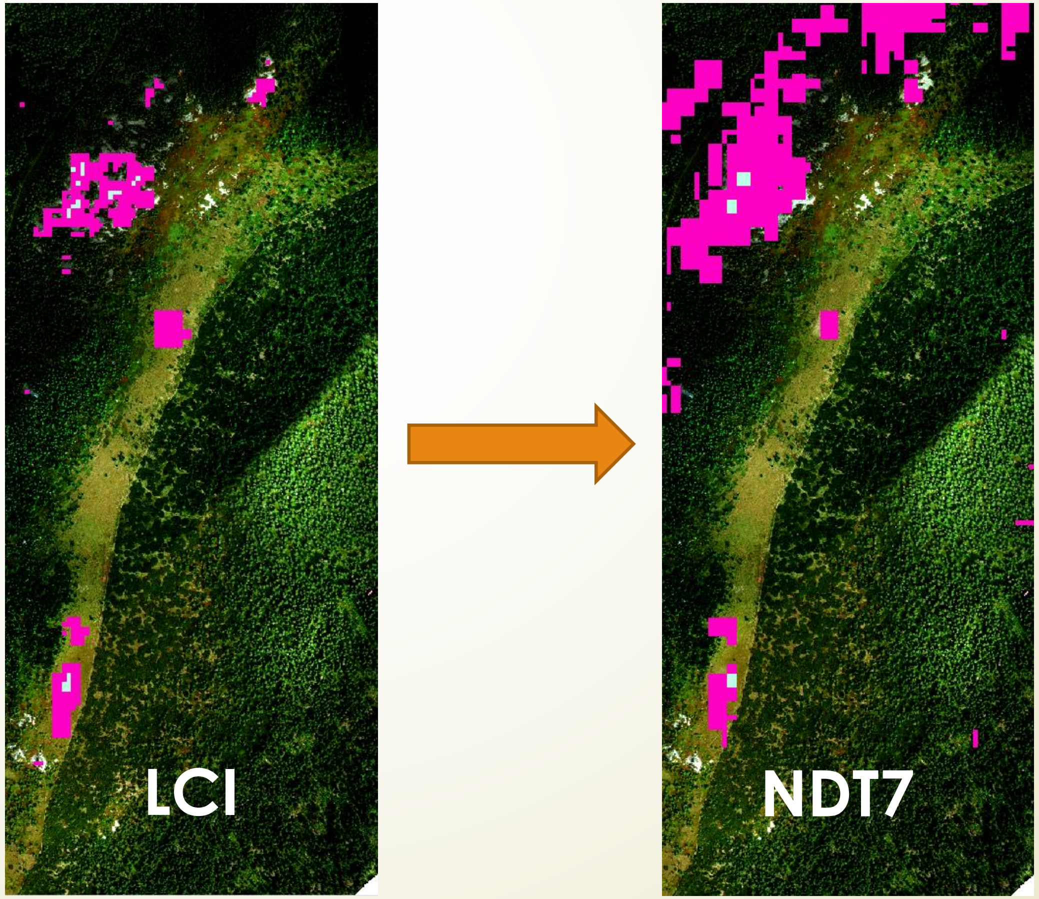
YEARS 2011 – 2015: **Landsat 5,7,8** imagery (res. 30m)





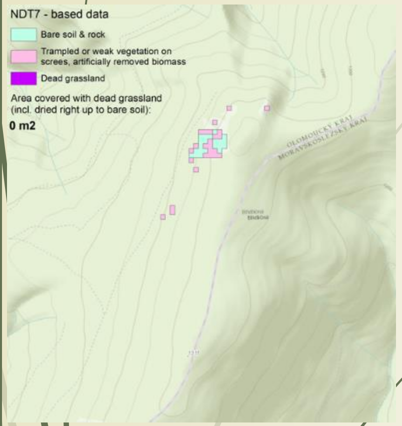
LCI was not possible to use, as Landsat does not have a Red Edge band!

Calibration from LCI to NDT7 index, using **2015 year as a proxy** (images of all sensor types are available for 2015)

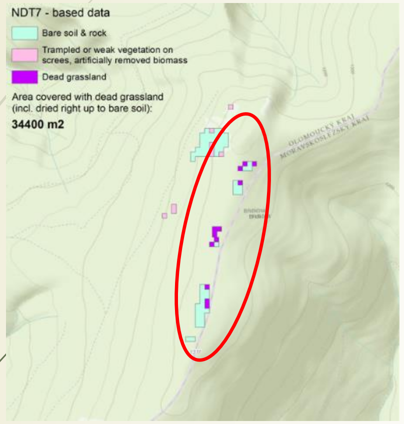


Retrospective analysis Břidličná 2011 - 2021

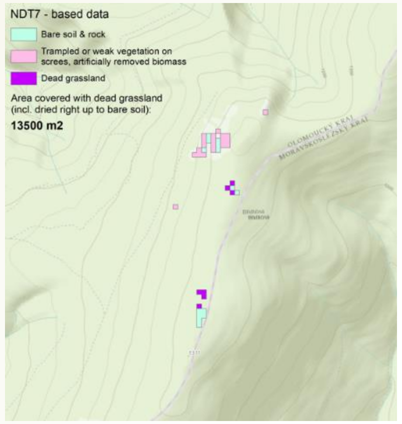
based on Sentinel-2 imagery (LCI) and Landsat 5,7,8 imagery (NDT7)



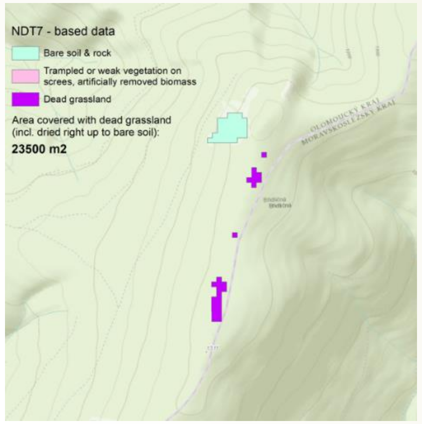
2011



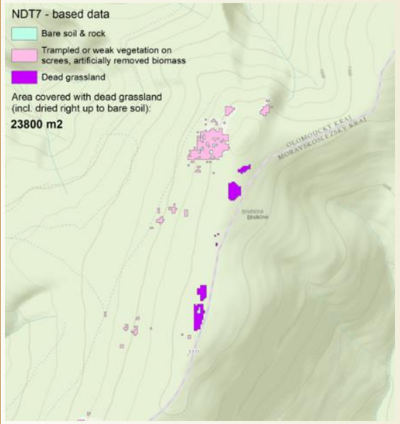
2012

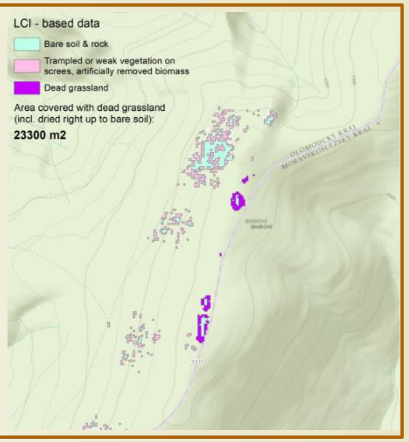


2013

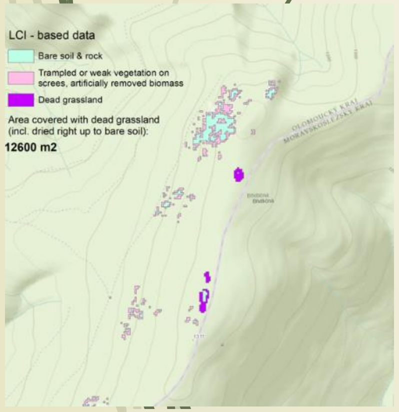


2014

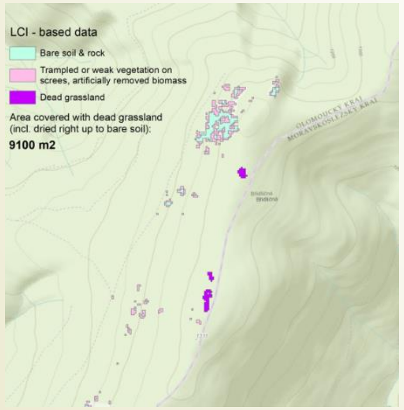




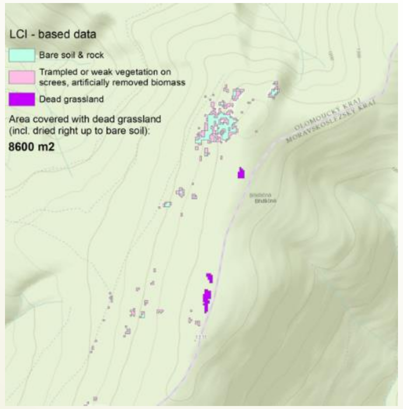
2015 (NDT7) ⟷ 2015 (LCI)



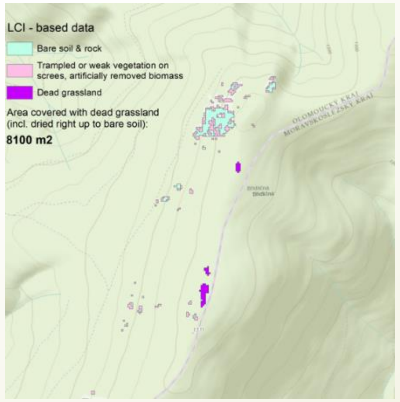
2016



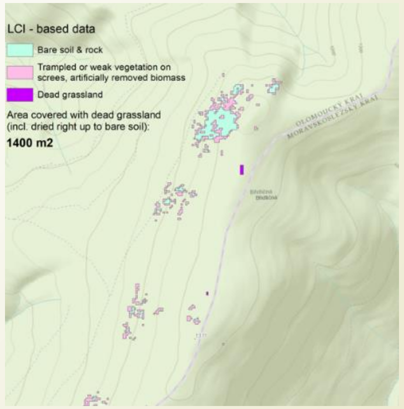
2017



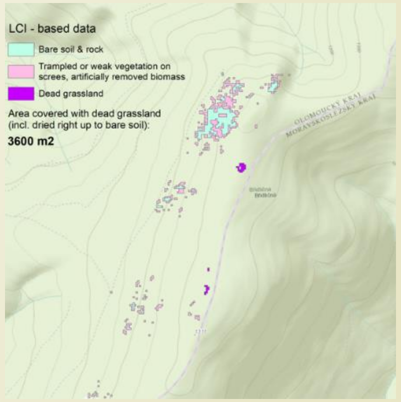
2018



2019



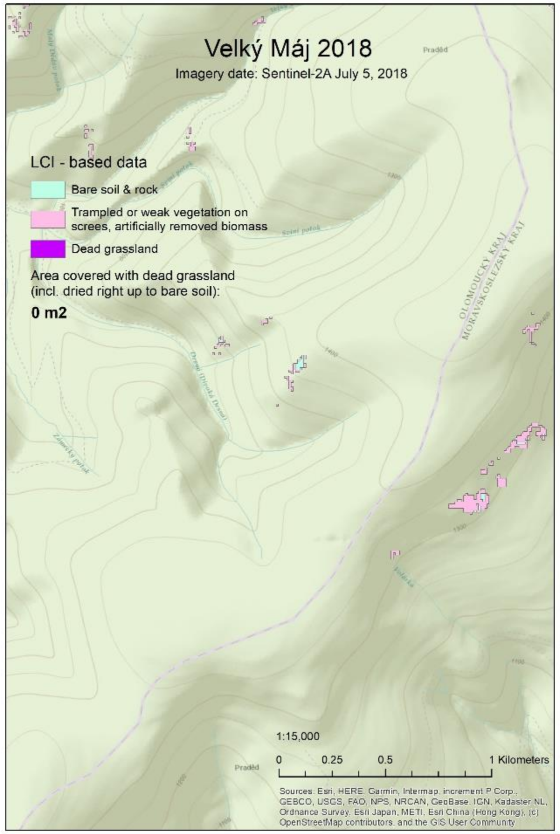
2020

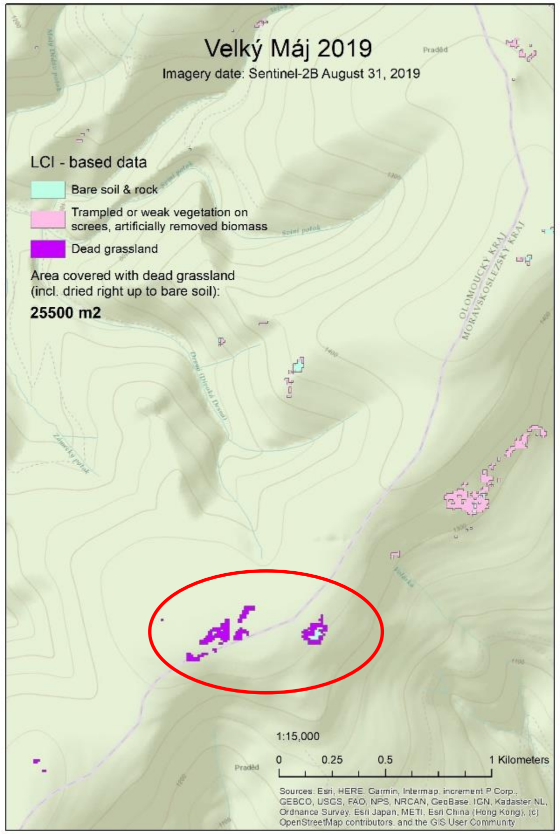


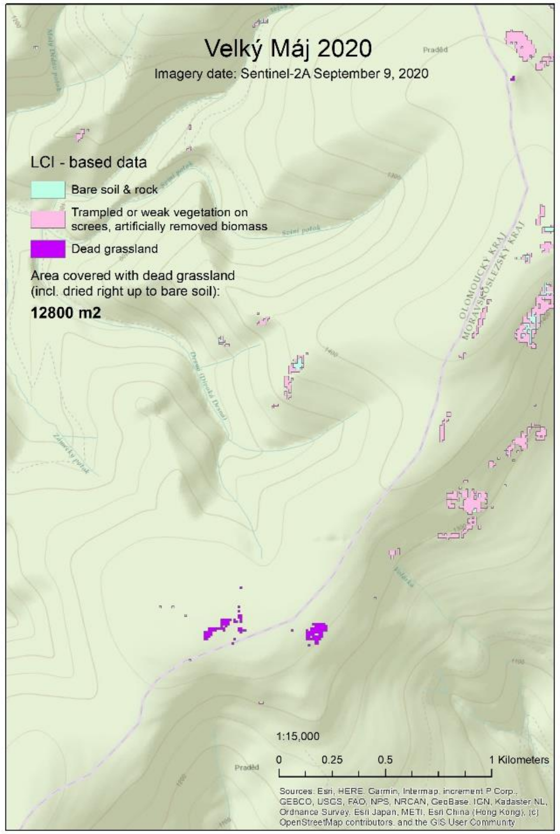
2021

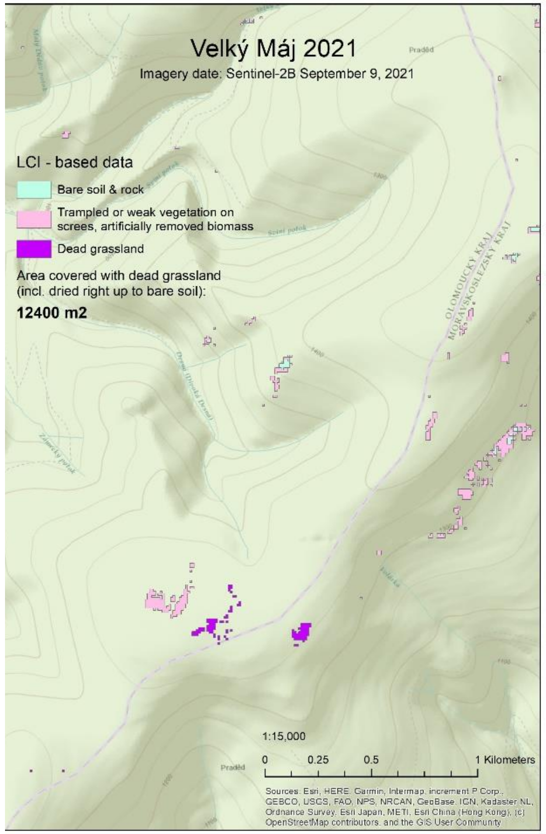
Retrospective analysis Velký Máj 2018 - 2021

based on Sentinel-2 imagery, LCI







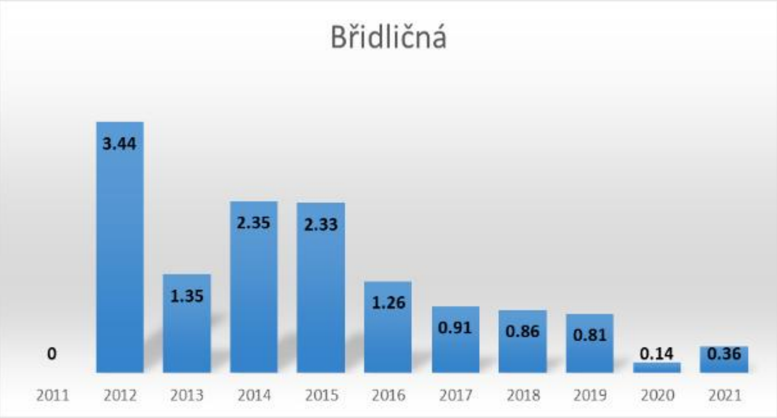


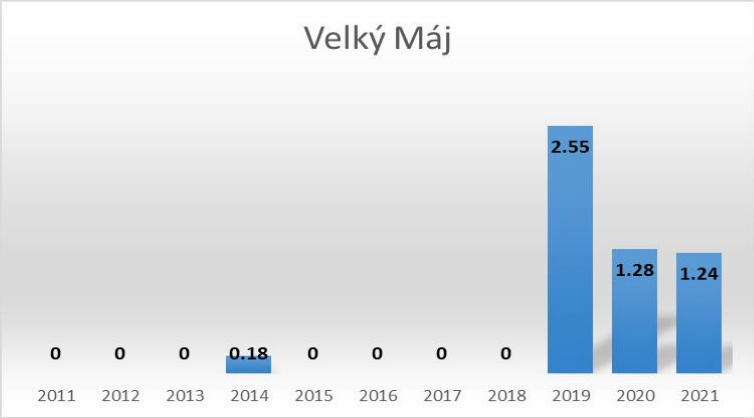
RESULTS: Dead grassland cover dynamics, ha

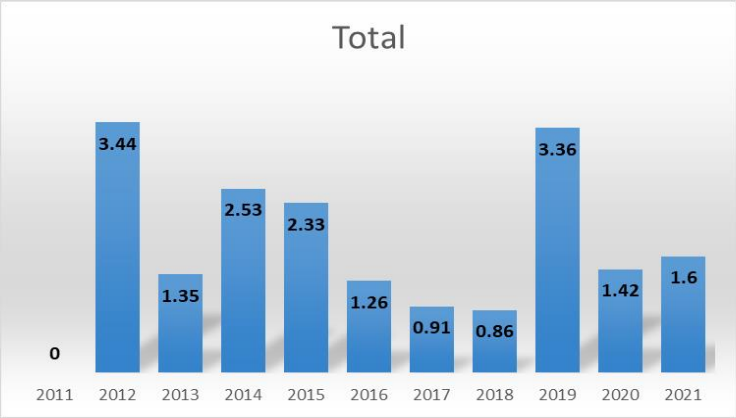
Year	Břidličná	Velký Máj	Total
2011	0	0	0
2012	3.44	0	3.44
2013	1.35	0	1.35
2014	2.35	0.18	2.53
2015	2.33	0	2.33
2016	1.26	0	1.26
2017	0.91	0	0.91
2018	0.86	0	0.86
2019	0.81	2.55	3.36
2020	0.14	1.28	1.42
2021	0.36	1.24	1.6

CONCLUSIONS

There were two massive dying events: in 2012 & 2019 (~3.5 ha of dying each). Dying of grasslands was sudden and massive, simultaneously covering the comparatively large areas; however, there were located in particular places (not widespread). Then, over time, the grass has been gradually recovering.

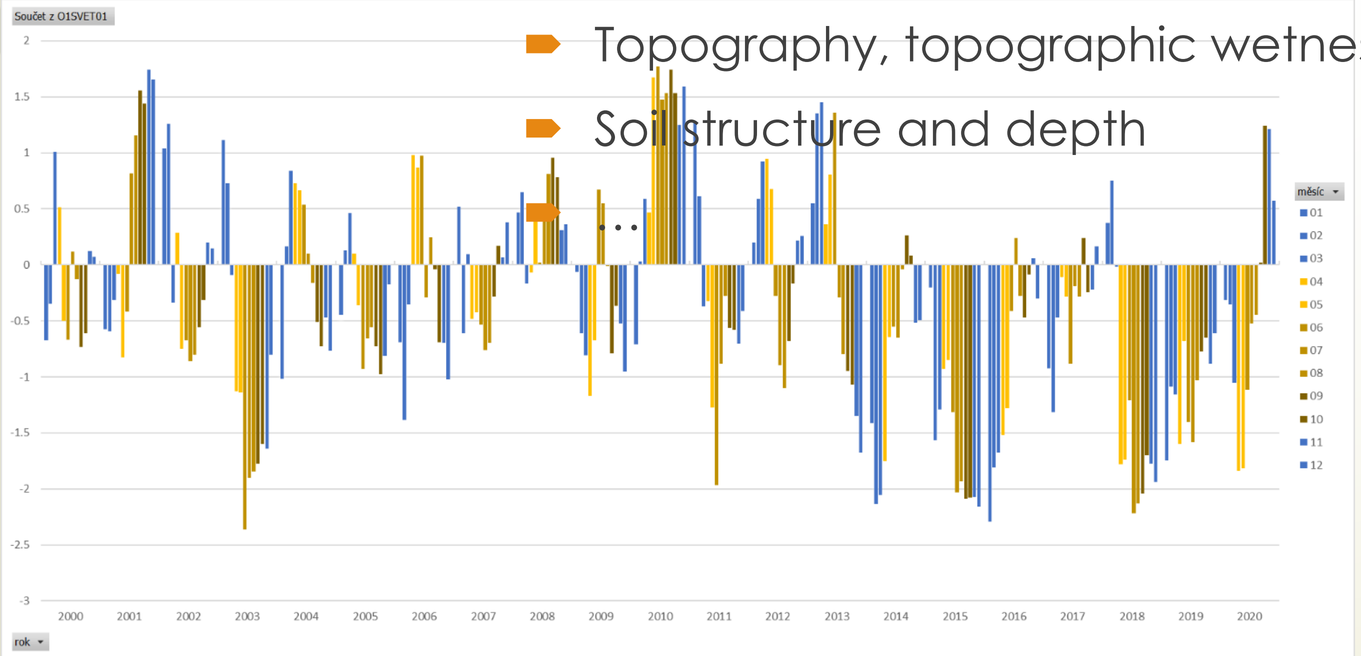


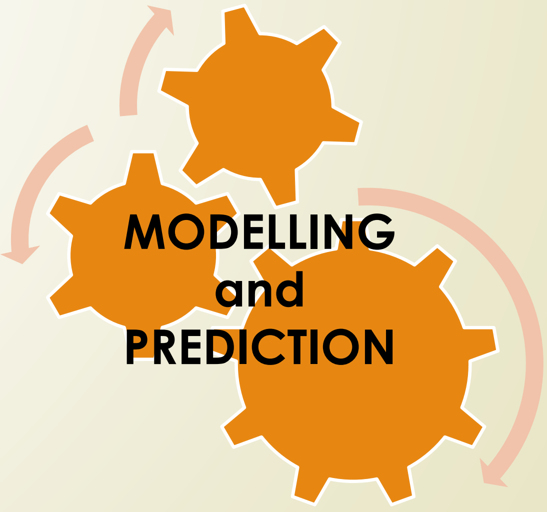




Future steps: studying the reasons of grassland dying

- Dead grassland distribution detected by RS techniques
- SPEI: The Standardised Precipitation-Evapotranspiration Index (on long-term meteorological data)
- In-situ measurements of soil moisture and temperature
- Data on winter/summer LIDAR-based DEM ⟶ estimation of snow cover depth as a source of water
- Topography, topographic wetness index (TWI)
- Soil structure and depth
- …





2. Mapping subalpine vegetation

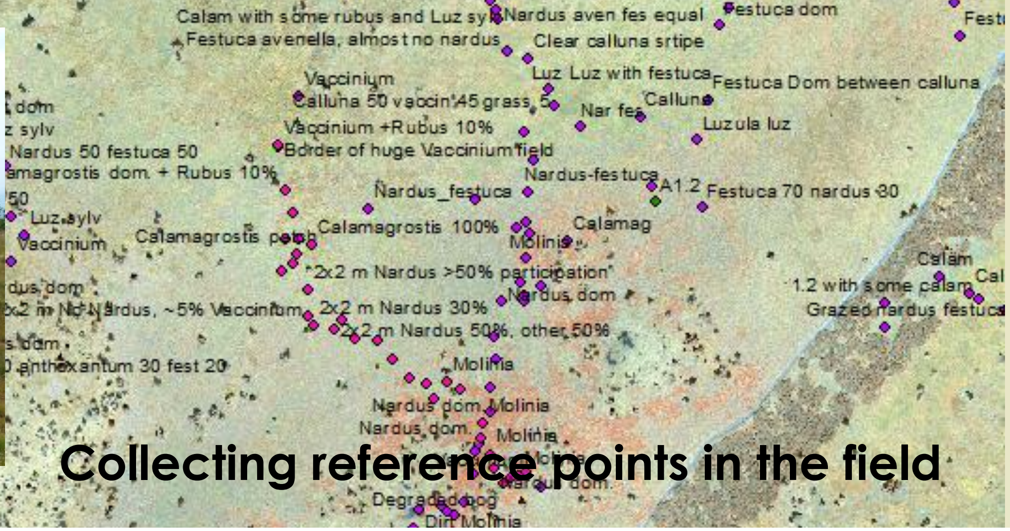
Input: July, 2022 CASI/SASI & drone imagery

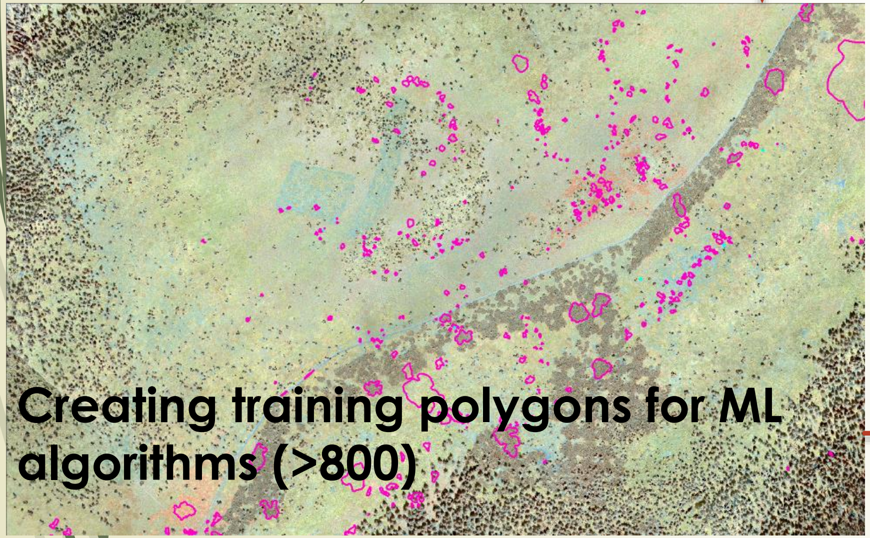
Methods: machine learning algorithms: Maximum Likehood, Random Forest, Convolutional Neural Network

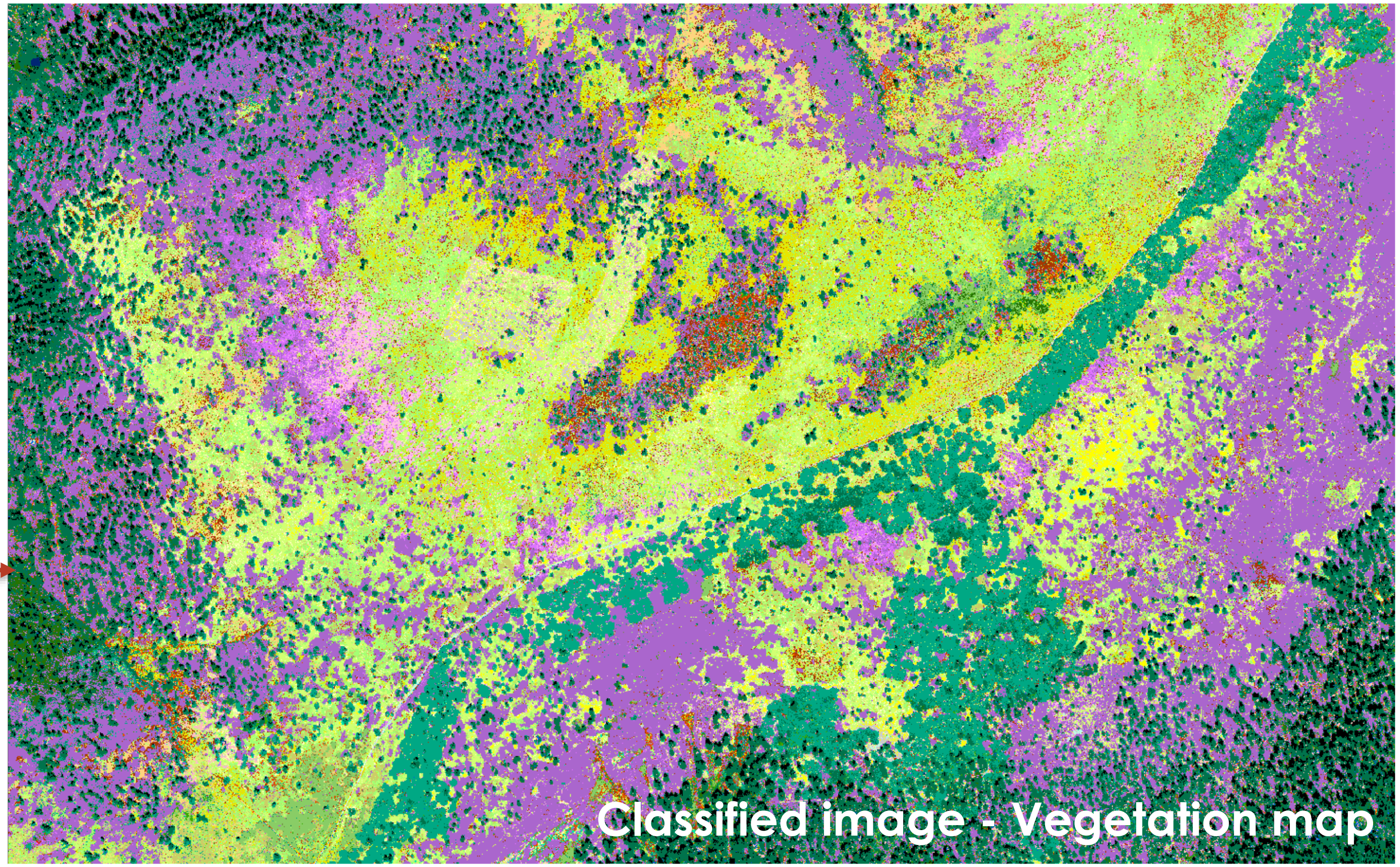
Legend:

kód biotopu	název biotopu	new_code	description
A1.1	Vyfoukávané alpínské trávníky	A1.1	Avenella flexuosa (mostly) loose grassland
A1.2	Zapojené alpínské trávníky	A1.2	Dense Festuca supina dom., Festuca+Nardus
		A1.2_Pol	Polytrichum pillows
		A2	mixed Calluna + Vaccinium
A2.1	Alpínská vřesoviště	A2.1	Calluna dom.
A2.2	Subalpínská brusnicová vegetace	A2.2	Vaccinium dom.
A4.1	Subalpínské vysokostébelné trávníky	A4.1_main	Calamagrostis villosa & Luzula luzuloides dom.
		A4.1_Mol	Molinia caerulea dom.
		A4.1_LS	Luzula sylvatica homogenous fields
		A4.1_D_A	Deschampsia & Agrostis dom. (Mala Kotlina)
A4.2	Subalpínské vysokobylinné nivy	A4.2	Adenostyles alliariae & other, incl. nitrofilious
A4.3	Subalpínské kapradinové nivy	A4.3	Athyrium distentifolium dom.
A6A	Acidofilní vegetace alpínských drolin	A6A	Screes
		A6B	Cliffs
A7	Kosodřevina	A7	Pinus mugo
A8.2	Vysoké subalpínské listnaté křoviny	A8.2_Sal	Salix sp.
		A8.2	Broad-leaved trees undefined
T2.1	Subalpínské smilkové trávníky	T2.1	Nardus stricta dom. (50-100%)
R3.4	Degradovaná vrchoviště	R3.4	Degraded raised bog
		R3.4_W	Open water hollows inside bogs
R1.5	Subalpínská prameniště	R1.5	Subalpine springs
(SM)	(smrky)	SM	Picea abies
(BK)	(buky)	BK	Carpinus betulus
		JC	Juniperus communis
		BL	Open soil, bare land (>50%)
		DG_50	Dead grassland patches >50% coverage
		DG_25	Recovering dead grassland patches (~25% of dead coverage)
		DW	Dead wood


Input image


Calam with some rubus and Luz sylv
Nardus aven fes equal
Festuca dom
Festuca avenella, almost no nardus
Clear calluna srtipe
Vaccinium
Calluna 50 vaccin 45 grass 5
Luz Luz with festuca
Festuca Dom between calluna
Nar fes
Calluna
Vaccinium +Rubus 10%
Luzula luz
Nardus 50 festuca 50
Border of huge Vaccinium field
Nardus-festuca
Nardus_festuca
A1.2
Festuca 70 nardus 30
Luz sylv
Vaccinium
Calamagrostis 100%
Calamag
Molinia
2x2 m Nardus >50% participation
Calam
1.2 with some calam
Nardus dom
2x2 m Nardus 30%
Grazed nardus festuca
2x2 m Nardus 50%, other 50%
Molinia
Nardus dom Molinia
Nardus dom
Molinia
Collecting reference points in the field


Creating training polygons for ML algorithms (>800)


Classified image - Vegetation map

Thank you for attention!

kachalova@vukoz.cz
houska@vukoz.cz