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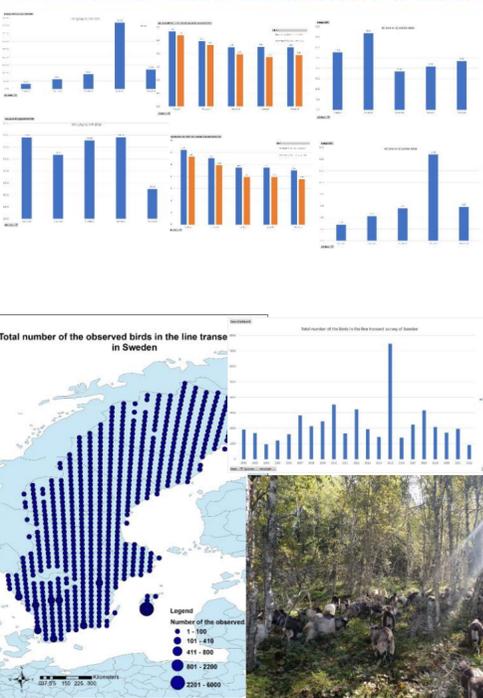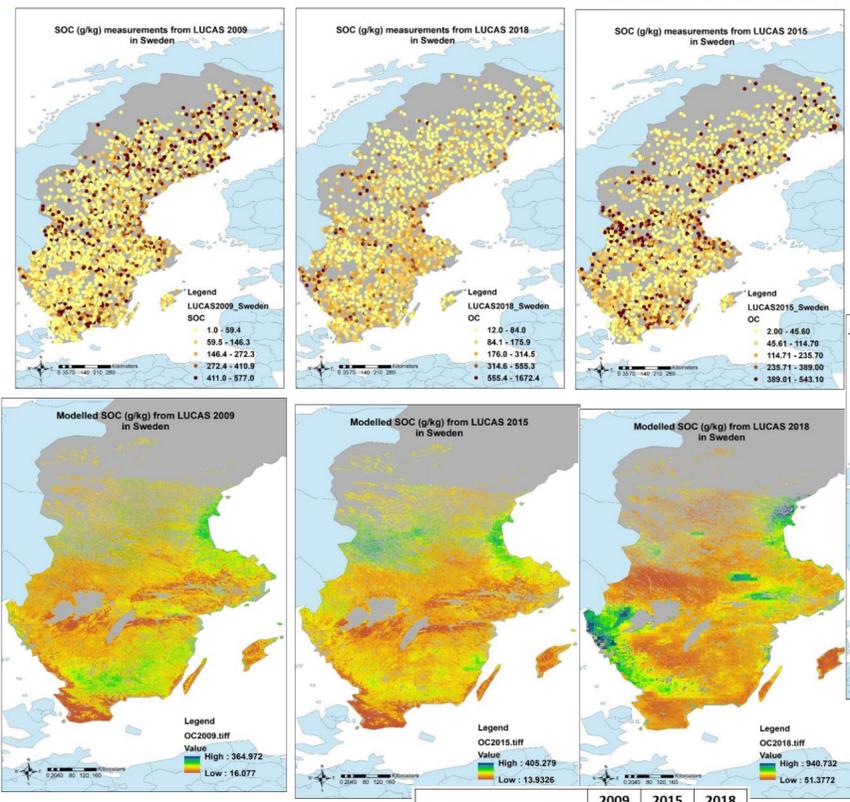## Monitoring ecosystem and soil health through advanced Earth Observation technologies – Mattmar Sweden case study.

Ece Aksoy (PhD), Durukan Duru (RegenSense), Ayhan Gurcam (RegenSense)

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SOC (g/kg) measurements from LUCAS 2009 in Sweden

SOC (g/kg) measurements from LUCAS 2018 in Sweden

SOC (g/kg) measurements from LUCAS 2015 in Sweden

Modelled SOC (g/kg) from LUCAS 2009 in Sweden

Modelled SOC (g/kg) from LUCAS 2015 in Sweden

Modelled SOC (g/kg) from LUCAS 2018 in Sweden

Total number of the observed birds in the line transect in Sweden

Sweden – LUCAS data

The main problem of this region is overall ecosystem health has been decreased during the last decades mainly due to management choices on its major landscapes: Commercial forest plantations. These ecosystems' complex dynamics need properly managed animal impact and grazing integration into their forest canopies. Lack of this integration feeds unhealthy and unstable soil cover due to lack of energy fluxes and photosynthesis, as well as weak water absorption and retention.
Also calcareous and strongly acidic soil structure... Lowest observation of the bird species.

Mattmar- RegenSense Ecosystem Health Monitoring

www.regensense.com

ayhan@regensense.com

	2009	2015	2018
SOC average Sweden	120.35	125.41	151.52
SOC average Mattmar	146.31	171.65	140.38

	2009	2015	2018
pH (CaCl2)	4.01	4.07	3.97
pH (H2O)	4.75	4.61	4.7
Organic carbon (g kg-1)	126.86	112.25	125.58
Carbonates (g kg-1)	1.8	1	3
Phosphorous (mg kg-1)	5.2	32.85	30

In this study, impacts of the holistic planned grazing, during 4 moths between 19 May to 15 September 2022 with 125 goats kids, as regenerative agriculture practices on ecosystem and soil health at Mattmar (Sweden) is monitored by quantifying overall condition with "Ecosystem health index" approach of RegenSense (Aksoy et. al., 2024).

In this holistic and innovative approach, ecosystem health and key ecosystem indicators are measured and monitored from different aspects by combining the field data with high resolution time-series satellite data with the help of ML modelling to better describe the land dynamics (both opportunities and problems) and understand the norms of those specific ecosystems.

In this methodology, we analyzed below main 4 ecosystem processes, together with several sub-indicators (36 indicators in total) to reflect different ecosystem functions, for evaluating and monitoring overall ecosystem health in detail:

1. Soil properties and nutrients,
2. Water cycle and balance,
3. Energy cycle,
4. Biodiversity and ecosystem functions.

All datasets and indicators under those 4-ecosystem processes were obtained from several different satellites in different spatial and temporal resolutions, such as Sentinel-1, Sentinel-2, Landsat, analyzed for long-term averages (most of them 4 years 2020-2021-2022-2023, some others 20-years term) and seasonally (4 seasons; December to February, March to May, June to August and September to November). The indexes for each of the ecosystem processes were created, based on the detailed baseline information, then the values were classified based on the scientific threshold and scored accordingly. Overall estimation of ecosystem health as EHI matrix was derived from the combination of those each indexes, namely "**S-Index:** Soil Quality Condition", "**E-Index:** Ecosystem and Biodiversity Quality Condition", and "**W-Index:** Water and Energy quality Condition"
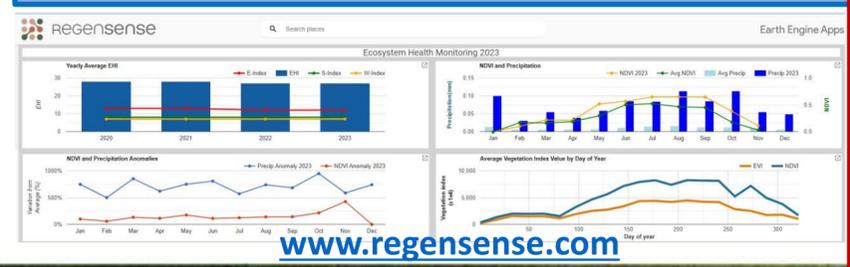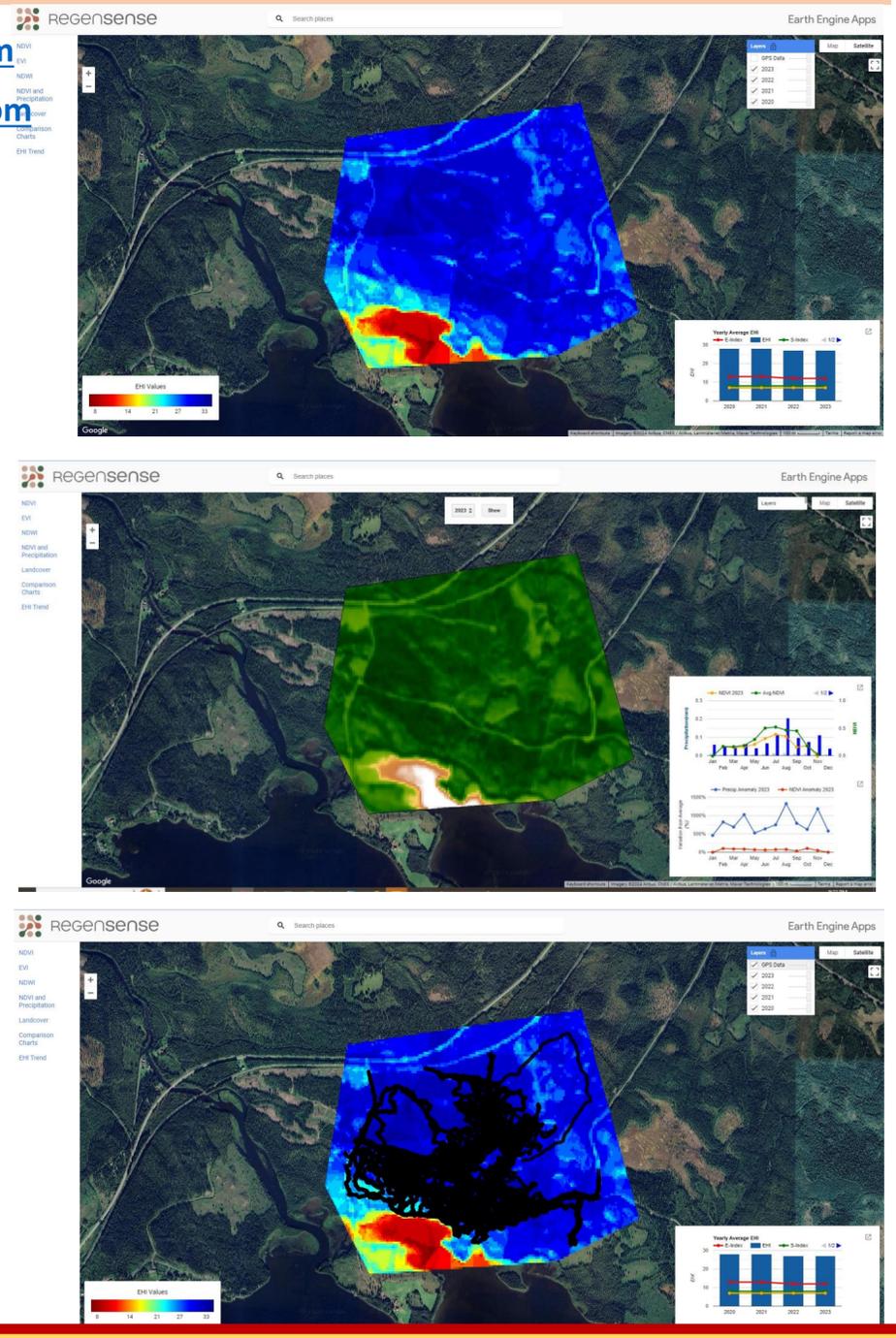
➢ Monitoring ecosystem health in holistic way and in different environments & applications is extremely important to improve the monitoring soil health.
➢ LUCAS data alone is not sufficient, feeding the LUCAS measurements with combination of other data sources collected from other landcovers is key.
➢ To improve soil and overall ecosystem health in Sweden, holistic grazing management is required. We believe that facilitating participatory processes and bringing relevant stakeholders together for constructive dialogue would remove barriers towards that end. In this context, leading hubs that operate in the region towards this, such as Fjällbete, Regenerativt Sverige and RegenHive - Jämtland CIV can be accelerated through Living Lab and Lighthouse frameworks of EU.

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