Mapping the deviation from optimum livestock density in the grassland agroecosystems of Romania within and outside the Natura 2000 Network

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Grassland agroecosystems:

- important role in Europe and worldwide; their ecosystem services are shared between agricultural production and nature conservation.
- **increasingly degraded** in the last century - reduction in biodiversity, vegetation coverage, plant height, and biomass production
- ecological problems - loss of biodiversity, carbon sink, and water storage capacity; intensification of soil degradation and dust storms.
- up to 50% of grasslands are affected worldwide; direct human activities (land-use changes) ~ 66%, climate change ~ 20%.
- Romania, low intensity agriculture, small-scale farming - grasslands with high biological diversity; **changing**.
- data on optimal livestock density for sustainable and accurate grazing management plans, (socio-economic and nature conservation) **not yet available in Romania**.

Objectives

- develop a GIS toolbox for the spatial analysis of the optimal livestock density (OLD) inside and outside of the Natura 2000 protected areas
- generate detailed statistics on the deviation from the OLD by spatial modeling (GIS).
- model the spatial distribution of the deviations from OLD - quantify and map its effect on the grassland degradation status.

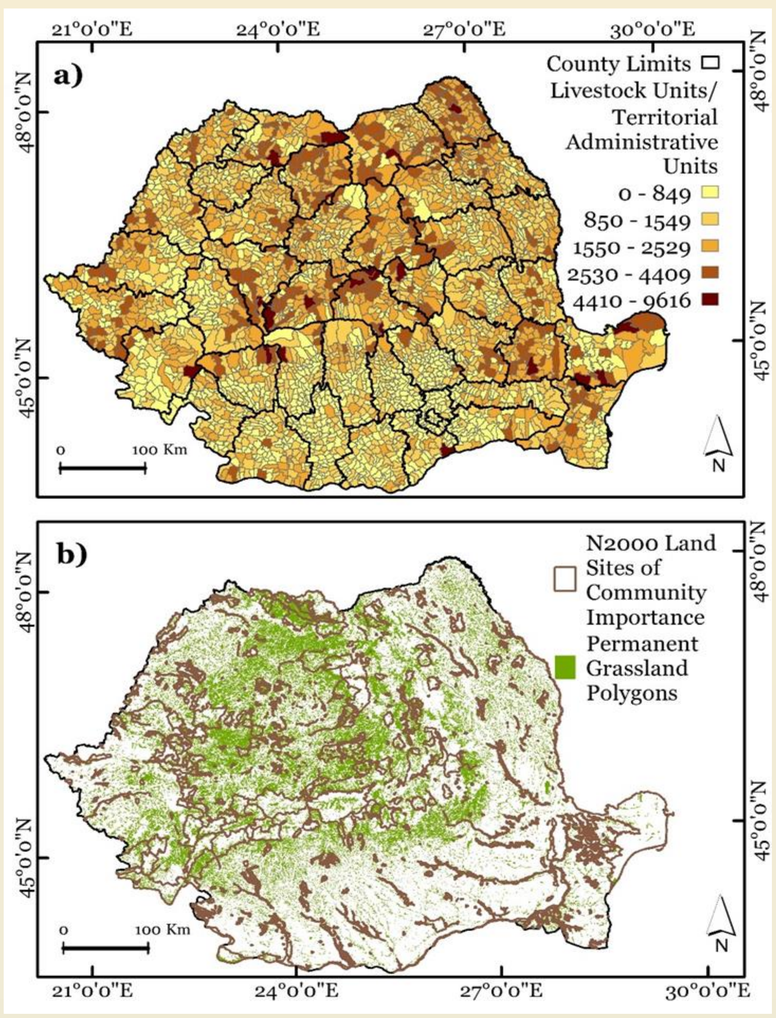

Fig 1. Livestock distribution in the Territorial Administrative Units from Romania (a). The permanent grassland habitats and the limits of the N2000 Sites of Community Importance from Romania (b).

Methods

The model includes:

- all the Permanent Grassland polygons (GP) (33529.42 km^2) in the Land Parcel Identification System from Romania.
- spatial data on the 435 Romanian Sites of Community Importance (N2000 SCI) (total area 40451.91 km^2)
- dataset - numbers and types of livestock from 41 counties (3177 localities-TAU) - National Statistics Institute of Romania.
    - livestock types: cattle, sheep, goats, horses, donkeys, and mules; livestock numbers converted into Livestock Units (LU) using specific coefficients from official Romanian guidelines (Fig. 1; Fig 2)

Two scenarios were considered for the grassland habitats included in N2000 SCIs.

1. Optimum Livestock Density suitable for grasslands with predominant socio-economic purpose (OLD_E). (all the grassland habitats of Romania);
    - OLD_E (LU/ha) takes into account different ecological and production characteristics of grassland habitat types from the three main altitude belts: 0.46 (20-200 m), 0.6 (201-800 m) and 0.9 (801-2544 m).

2. lower OLD, lower intensity grazing, favoring biodiversity conservation grasslands situated within N2000 SCIs)
    - OLD_B, 0.45 LU/ha although large ecological variation in Romania might require more specific values for different grassland habitat types/altitude belts.

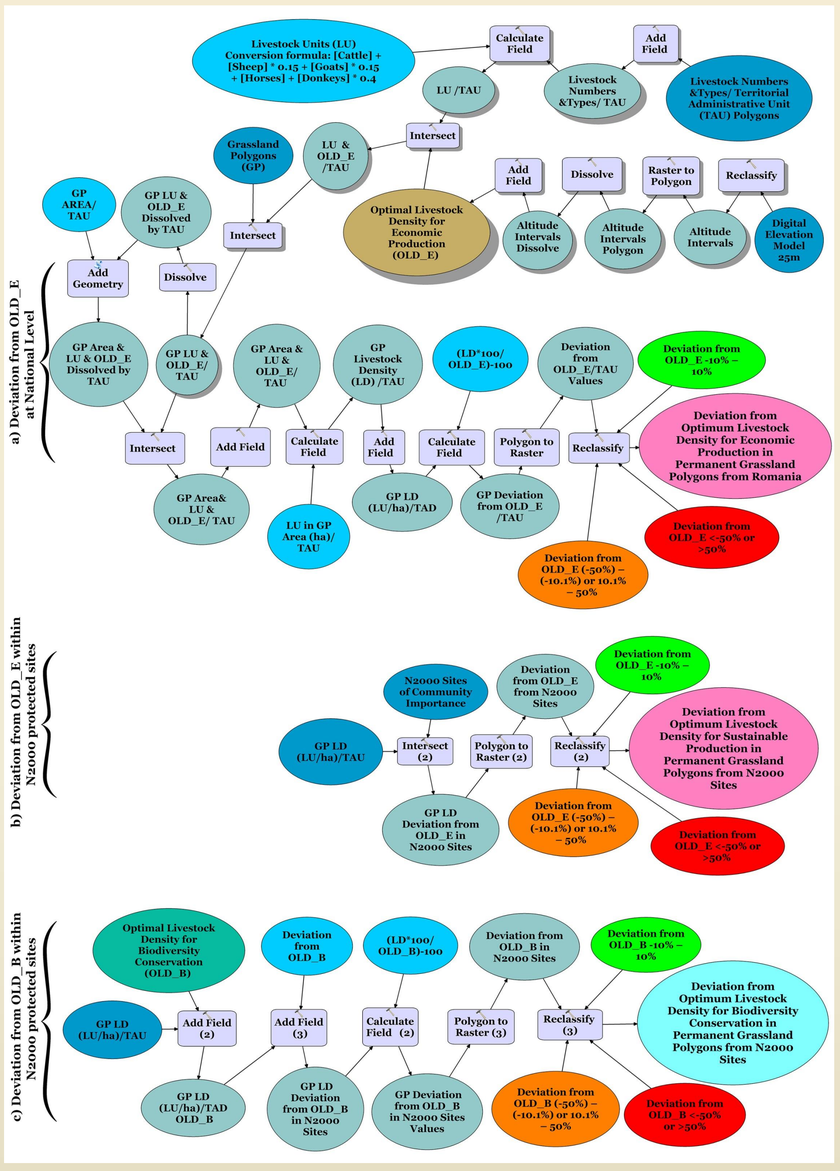

Fig. 2. The GIS tools and models generated for the analysis of the:
a) grassland habitats at national level, using deviations from the optimal livestock for socio-economic production (OLD_E);
b) grassland habitats from the N2000 SCIs, using deviations from the optimal livestock for socio-economic production (OLD_E);
c) grassland habitats from the N2000 SCIs, using deviations from the optimal livestock for biodiversity conservation (OLD_B).

The difference between the current LD of a grassland and the optimum livestock density for the respective area and conditions represents the deviation from OLD. The equation for generating the Deviation from Optimum Livestock Density (DEV_{OLD}) in each grassland polygon is:

$$DEV_{OLD} = \frac{LD * 100}{OLD} - 100$$

LD – Livestock Density as Livestock Units/hectare (LU/ha)
OLD – Optimum Livestock Density for the grassland polygon

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RESULTS

Grassland habitats at national level (Fig. 3a):

- more than half of the grassland area is subject to major impact and degraded, most of it from overgrazing; less than 10% is not impacted by grazing livestock.
- of the total national grassland area, 5815.75 km² (17.34%) are situated within N2000 sites; substantial presence of agricultural activities within the protected areas.

Grassland habitats within Natura 2000 SCIs: **OLD Economic** scenario (Fig. 3b):

- the major impact – degraded area slightly lower than at national level, 50.34% vs. 52.45%.
- abandonment is a more important impact factor.
- high percentage of N2000 grassland habitats prone to major impact and degradation - the use of the lower, conservation-oriented optimal LD (of 0.45 LU/ha) is recommendable.

Grassland habitats within Natura 2000 SCIs: **OLD Biodiversity** scenario (Fig. 3c):

- very similar proportion of strongly impacted – degraded area (49.82%), but predominance of overgrazing - need to reduce the livestock density in these areas.

Solutions:

- simplest and most straightforward - optimize the spatial distribution of the LD, particularly where neighboring TAUs experience opposite tendencies.
- further approach – employ the identified spatial patterns of grazing intensity to address specific areas, where:
- intensity of agricultural practices is divergent from optimum
- these and nature conservation efforts overlap.

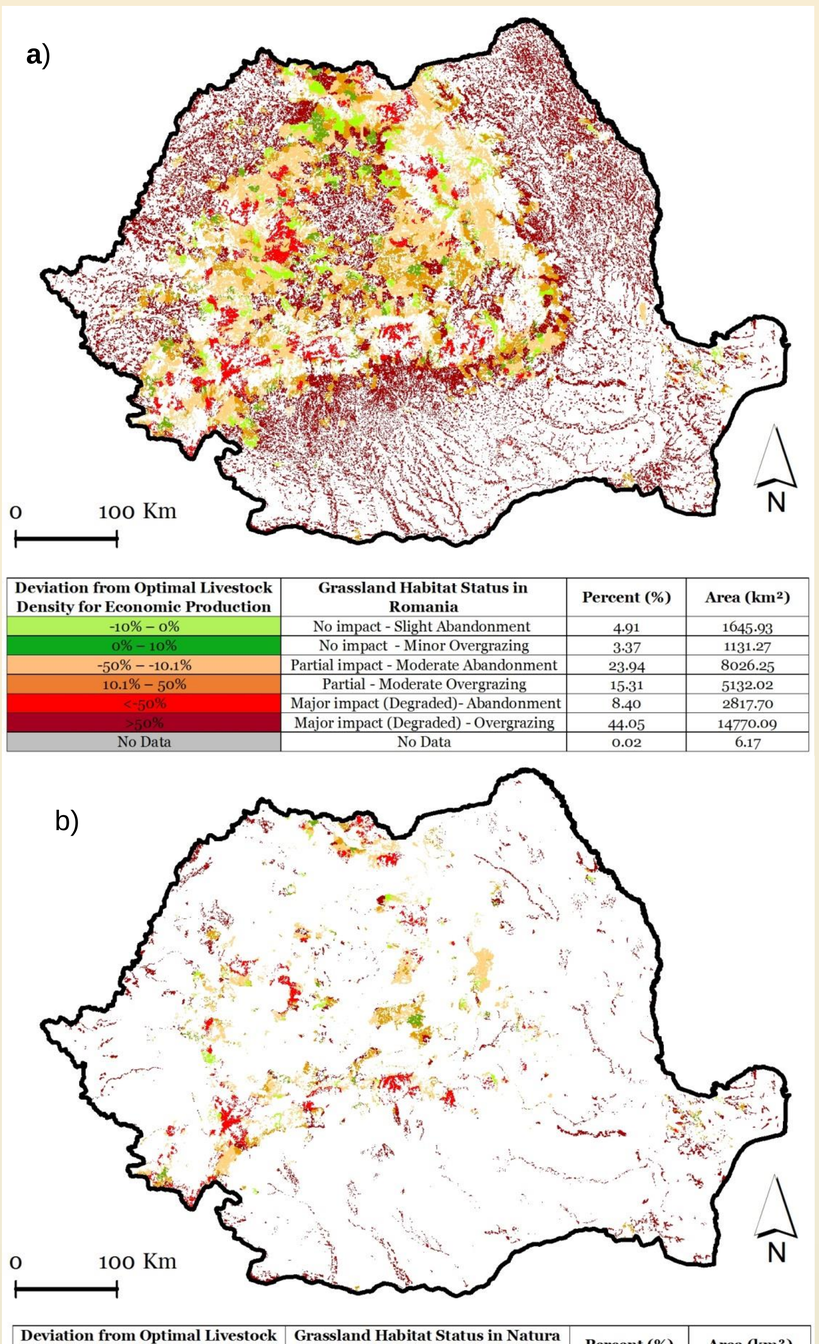
CONCLUSIONS

Detailed statistics obtained:

- basis for designing optimized grazing and protection measures to prevent grassland degradation.
- support policies aiming at a future conflict-free combination of agricultural production and nature conservation.

The developed GIS toolbox (Fig. 2):

- environmental conflict anticipation and management of the grassland habitats to achieve both socio-economic and conservation targets.
- particularly useful in the case of protected areas.
- is flexible and can be easily adapted similar scenarios in other geographic areas.



Deviation from Optimal Livestock Density for Economic Production	Grassland Habitat Status in Romania	Percent (%)	Area (km²)
-10% – 0%	No impact - Slight Abandonment	4.91	1645.93
0% – 10%	No impact - Minor Overgrazing	3.37	1131.27
-50% – -10.1%	Partial impact - Moderate Abandonment	23.94	8026.25
10.1% – 50%	Partial - Moderate Overgrazing	15.31	5132.02
<-50%	Major impact (Degraded)- Abandonment	8.40	2817.70
>50%	Major impact (Degraded) - Overgrazing	44.05	14770.09
No Data	No Data	0.02	6.17

Deviation from Optimal Livestock Density for Economic Production	Grassland Habitat Status in Natura 2000 sites (SCI) from Romania	Percent (%)	Area (km²)
-10% – 0%	No impact - Slight Abandonment	3.46	200.77
0% – 10%	No impact - Minor Overgrazing	3.22	187.12
-50% – -10.1%	Partial impact - Moderate Abandonment	28.86	1675.35
10.1% – 50%	Partial - Moderate Overgrazing	14.13	820.14
<-50%	Major impact (Degraded)- Abandonment	19.81	1149.76
>50%	Major impact (Degraded) - Overgrazing	30.52	1771.86
No Data	No Data	0.01	0.32

Deviation from Optimal Livestock Density for Biodiversity Conservation	Grassland Habitat Status in Natura 2000 sites (SCI) from Romania	Percent (%)	Area (km²)
-10% – 0%	No impact - Slight Abandonment	3.74	216.92
0% – 10%	No impact - Minor Overgrazing	4.41	256.24
-50% – -10.1%	Partial impact - Moderate Abandonment	15.44	896.47
10.1% – 50%	Partial - Moderate Overgrazing	17.91	1039.88
<-50%	Major impact (Degraded)- Abandonment	8.03	466.45
>50%	Major impact (Degraded) - Overgrazing	50.46	2929.12
No Data	No Data	0.01	0.32

Fig. 3. The spatial distribution of impact and degradation at national level caused by the deviations from grazing optimum for the socio-economic production and biodiversity conservation scenarios and the deviation classes, status and their percentage and area at national level within and outside the Natura 2000 sites.