Remote sensing and GIS based ecological modelling of potential red deer habitats in the test site region DEMMIN (TERENO)

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Background

- The TERENO Initiative aims to study climate and land use changes as well as their regional impacts in order to formulate a sustainable socio-economic framework and estimate its ecological consequences (e.g. Heinrich et al., 2018, Bogena et al., 2019).
- In both cases, the strategic aim is to optimize the sustainable use and extraction of natural resources in order to protect natural capacities. In particular, the conservation and enhancement of biodiversity requires increasing attention.
- The above-mentioned land use change is more or less pronounced on different spatial and temporal scales (e.g. Schönwiese, 2008; Büntgen et al., 2013).
- The scientific community responded to the challenges by developing experiments and monitoring platforms (e.g. Osmond et al., 2004; Knorr et al., 2005, Mollenhauer, 2018).
- Recording biodiversity at regional and superregional levels under changing environmental conditions requires comprehensive monitoring based on sound concepts. Yet, the provision of extensive data sets, required for such monitoring, is cost and resource intensive.
- In the absence of specific quantitative datasets it is necessary to use every suitable and available data source to create as full a picture as possible of the complex interactions within ecosystems. In the following study, we will use an example to show how conclusions about the distribution of large mammals in a landscape dominated by humans can be derived from spatially and temporally uncertain data.

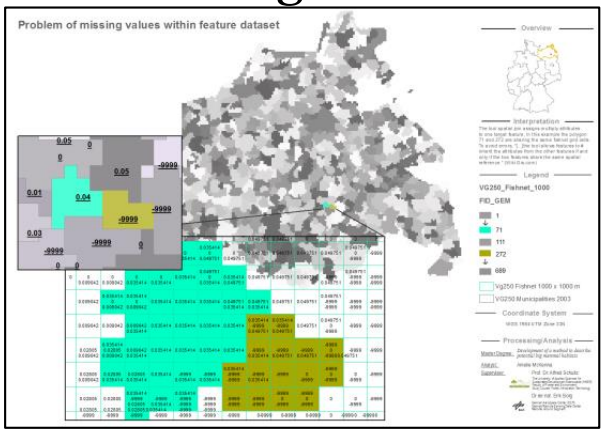
Objectives

The main objectives of the project are:

- Target-oriented pre-processing of uncertain and incomplete spatial ecological observation data (hunting data reports) and identification of correlated landscape structure metrics based on precise RS data (Global Forest Change)
- Development of a binary classifier for the prediction of habitat suitability of Red Deer
- Implementation and evaluation of the derived binary classifier within the test site region DEMMIN (TERENO)

Material and Methods

Test Site Region



Methods

- FRAGSTATS*
- Correlation Analysis
- Binary Logistic Regression

Available Data Base

- Global Forest Change (2000-2012) Remote Sensing Product (Hansen et al. 2013)
- Analogous list of Hunting Success Data (2006-2012) Observation data
- Digital Administrative data of Mecklenburg-Vorpommern (e.g. municipalities)
- Literature Studies / Ecological Studies (ecological relevant data) also see slide Nr.7

Landscape structure measures

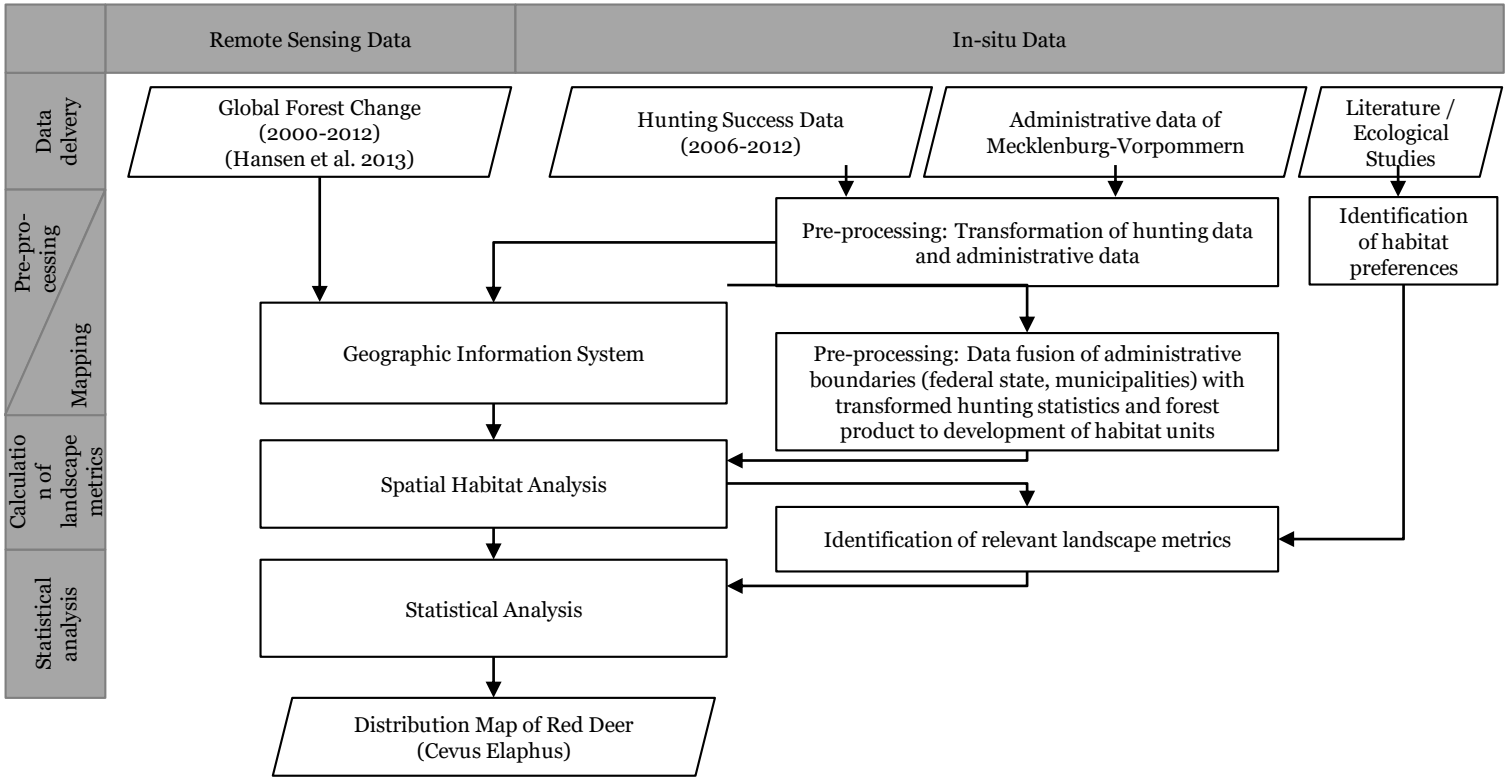
- Percentage of landscape (PLAND)
- Mean shape index (SHAPE)
- Edge density (ED)

} Class level

- Area-weighted mean radius of gyration (GYRATE)
- Effective mesh size (MESH)
- Contagion (CONTAG)

} Landscape level

Data processing chain



Binary classifier

Hypothesis

It is supposed that Red Deer habitat suitability is dependent on landscape structure and can be appropriately expressed with landscape structure metrics:

- Binary Logistic Regression is used as classifier (advantage: no particular data assumptions have to be fulfilled)
- area-wide classified habitats are divided in less or more preferred habitats based on statistical reasoning (habitat suitability 0 or 1) and serve as dichotomous dependent variable
- landscape structure metrics based on RS data serve as independent variables
- the derived regression function with unstandardized coefficients serves as binary classifier; standardized coefficients (King, 2007) allow comparative evaluation of input variables (that is ecological importance of metrics)

Habitat Model Output

Summary of output variables	
Nagelkerke R^2	Overall Classification
0.199	68.8

Habitat Model		
Landscape metrics	Unstandardized regression coefficient	Standardized regression coefficient
Contagion	-0.027	-0 .166
Edge density	-0.092	-0.065
Percentage of land	0.026	0.164

Habitat Model - Final				
Landscape metrics	B	Wald statistic	p-value of Wald chi-square statistics	Exp(B)
Contagion	-0.027	121.284	0.000	0.974
Edge density	-0.092	37.445	0.000	0.912
Percentage of landscape	0.026	379.739	0.000	1.027
Constant	0.719	13.620	0.000	2.052

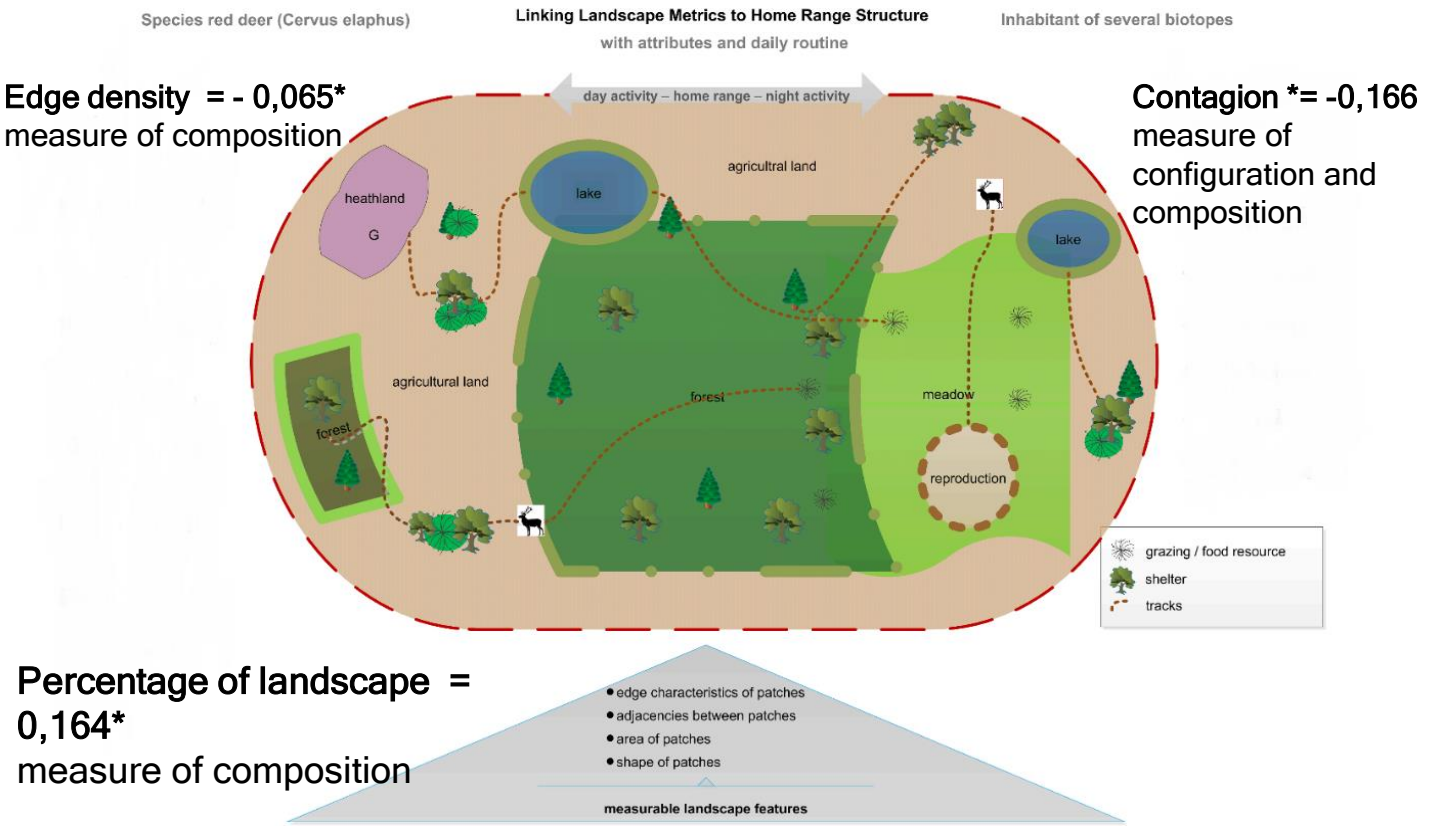
$$P(HSI = 1) = \frac{1}{1 + e^{-(b_o + b_1 * 0{,}027_1 + b_2 * 0{,}092 + b_3 * 0.02)}}$$

P (HIS=1) = predicts whether habitats are more or less preferred

b_o, b_1, b_2, b_3 = coefficient (or weight)

Link habitat attributes to red deer species

- Red deer responds primarily to landscape composition



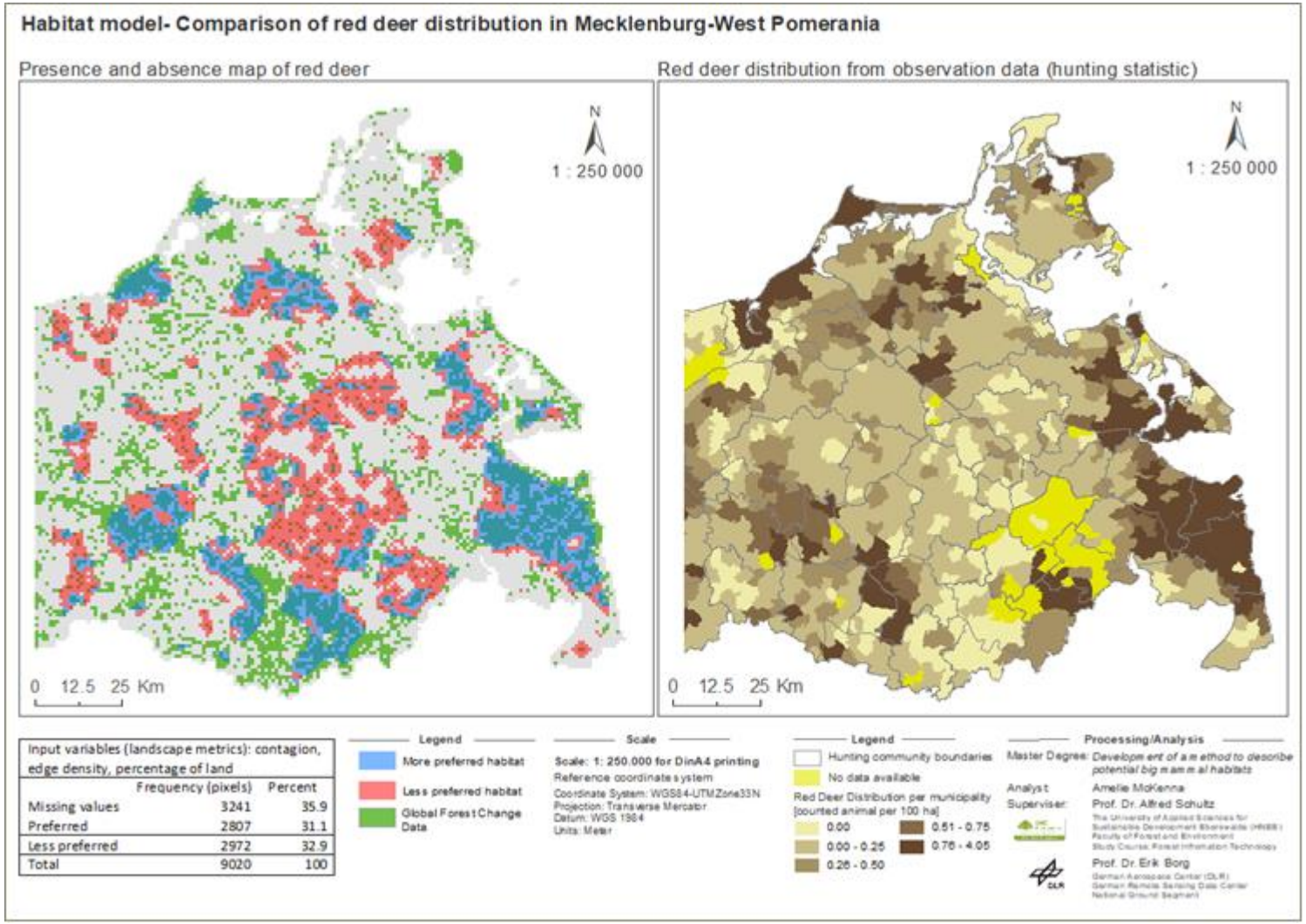
Edge density = - 0,065*
measure of composition

Contagion *= -0,166
measure of configuration and composition

Percentage of landscape = 0,164*
measure of composition

- *= Standardized b-coefficient

Habitat preference map



Discussion - Consequences

Core results

- A binary classifier for the prediction of red deer habitat suitability using logistic regression was developed and provided acceptable classification results
- Simple models can be derived by using spatio-temporal incomplete and uncertain in-situ-observation data and remote sensing based landscape metric data of high quality
- Calculation of standardized coefficient allowed better comparison, interpretation and evaluation of landscape metrics
- Red deer habitat preferences are successful described using landscape metric (CONTAG index, ED index, PLAND index), certainly the approach is adoptable to other big mammals with similar habitat preferences

Conclusions

- In order to achieve exactable results a great variety of different classification approaches have to be simulated
- The observation dataset is vulnerable to bias as it has limited spatio-temporal character and thus the assignment and averaging to municipalities lead to estimates rather than a fact
- The authors are certain that quantitative accuracy could be improved if detailed biotope data were provided with greater explicitness and further ecological parameters
- Quality of species observation data could be improved including other public data e.g. on traffic and accident

Literature

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Thank you for your attention!