NATURAL RESOURCES
INSTITUTE FINLAND

Unraveling the spatial scale of grouse habitat selection in the boreal forest landscape to improve forest management

Adriano Mazziotta




Context:

The characteristic spatial scale at which species respond strongest to their environment is unclear (Holland et al. 2004).

We know that:

- Scale dependency depends on the degree of environmental heterogeneity in the landscape (Lu and Jetz 2023).
- Different environmental attributes shape the species resource needs at multiple spatial scales (Stuber and Fontaine 2019).
- The response scale is determined by the habitat structure and composition (Wiens, 1989).




Holland, J. D. et al. (2004). Determining the spatial scale of species' response to habitat. Bioscience, 54(3), 227-233.

Lu, M., & Jetz, W. (2023). Scale-sensitivity in the measurement and interpretation of environmental niches. Trends in Ecology & Evolution, 38(6), 554-567.

Stuber, E. F., & Fontaine, J. J. (2019). How characteristic is the species characteristic selection scale?. Global Ecology and Biogeography, 28(12), 1839-1854.

Wiens JA (1989) Spatial scaling in ecology. Functional Ecology, 3(4), 385-397

We asked the following Questions:

(Q1) Does the spatial scale affect the accuracy of the grouse habitat models?

(Q2) Is there an optimal spatial scale for modelling grouse occupancy?

(Q3) Are there common predictors explaining grouse occupancy at different scales?

(Q4) Do habitat structure and composition affect occupancy differently at different scales?

Methods (summary):

- Occupancy patterns of four forest grouse species: from Finnish wildlife triangle census data.
- Forest variables: from Airborne Laser Scanning (Finnish Forest Centres) and satellite data (multi-source National Forest Inventory from Luke).

- Generalized Additive Mixed Models: to link grouse occupancy with forest characteristics.

- Scale effects: Predictors were aggregated at three biologically relevant spatial scales:

  - local level at forest stand scale,
  - home range level at 1 km radius,
  - regional level at 5 km radius.

Hazel grouse
(Tetrastes bonasia)

Black grouse
(Tetrao tetrix)

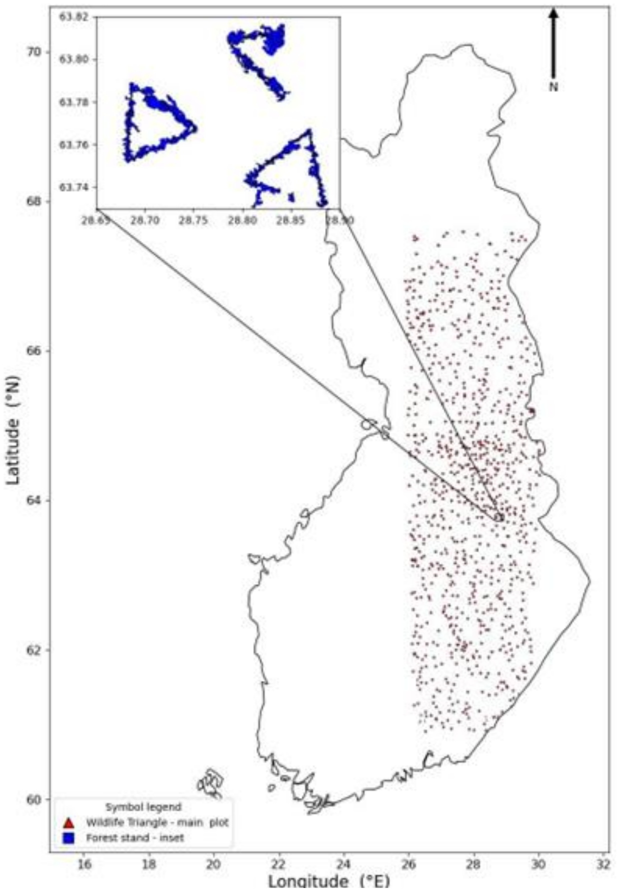
Capercaillie
(Tetrao urogallus)

Willow grouse
(Lagopus lagopus)

Methods:

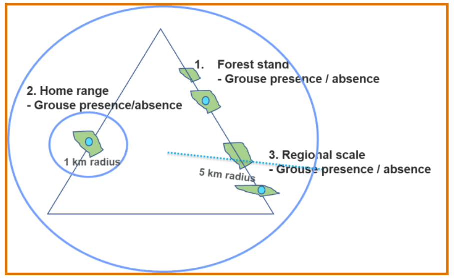
Finnish wildlife triangle census data

Study area: width: 225 km, length: 750 km,
Finnish boreal forest with Scots pine (Pinus sylvestris), Norway spruce (Picea abies), and birch (Betula spp.)



Locations of wildlife triangles for grouse species 2005-2019

Scales of analysis:



Predictors of forest structure and composition at 16 x 16 meter grid square :

Variable name	Units
Clear-felled area	ha
Total peat area	ha
Basal area	m2
Regional density 5-100 km	N. individuals / km^2
Canopy cover	%
Fertility class	-
Log of the Sampling effort	km2
Mean Height Norway spruce	m
Mean Height deciduous trees	m
Mean age	years
Mean diameter	cm
Mean diameter diversity index	-
Volume diversity index	-
Stem density Scots pine	N. stems
Stem density Norway spruce	N. stems
Stem density deciduous trees	N. stems
Stem density	N. stems
Stand Latitude	degrees N (°)
Stand Longitude	degrees E (°)
Interaction between lat and long	degrees NE (°)
Volume Scots pine	m3
Volume Spruce	m3
Volume deciduous trees	m3

Methods: GAMMs (Generalized Additive Mixed Models)

Stand-level Species Presence (1)/ Absence (0)	~	te (lat, long)	+	log(sampling effort)	+	Regional Density	+	forest variables	+	1 | Triangle
(1)		(2)		(3)		(4)		(5)		(6)

<u>Description of model elements:</u>

(1) Annual census data derived from wildlife triangles

~ Binomial function with logit link

(2) Spatial surface based on geographic coordinates

(3) Sampling effort = area covered by the segment of the sampling transect going through a forest stand

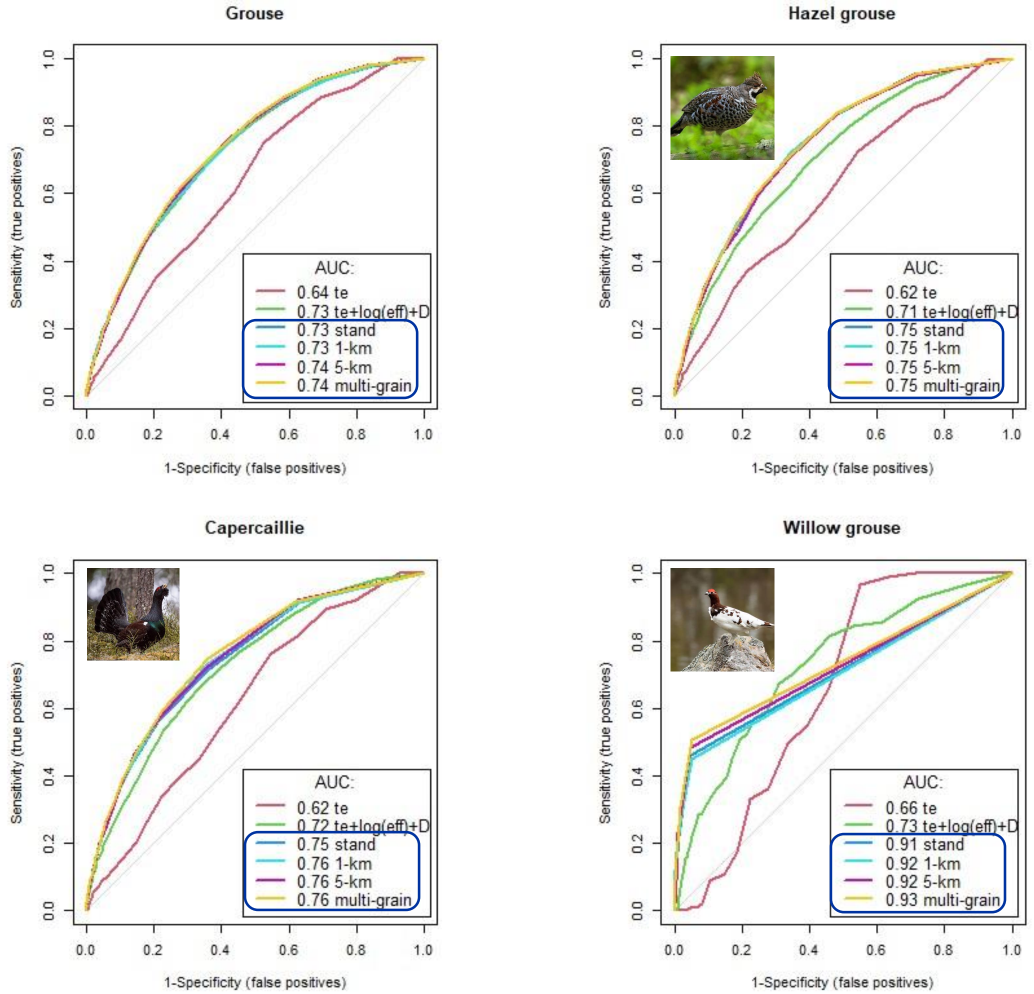
(4) Total density of each species grouse (incl. young) at radius 5-100 km (unit: individuals / km^2)

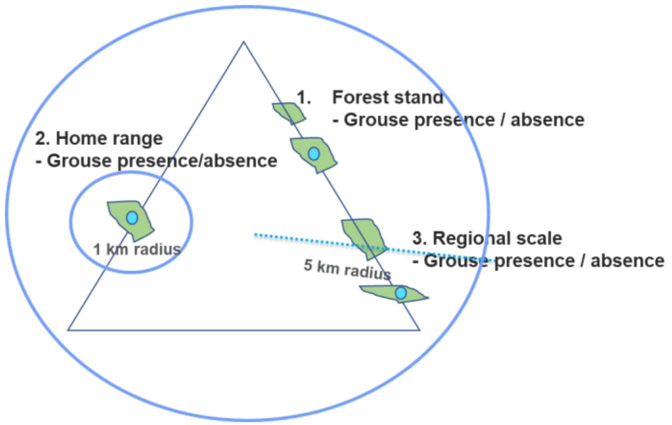
(5) Linear combination of forest variables = output from metsään.fi at local=stand scale, 1-km and 5-km scale

(6) random 'site' effect: triangle as a random effect within which stands are aggregated

Results: ROC curves for GAMM grouse models at stand, 1-km, 5-km and multi-grain scales

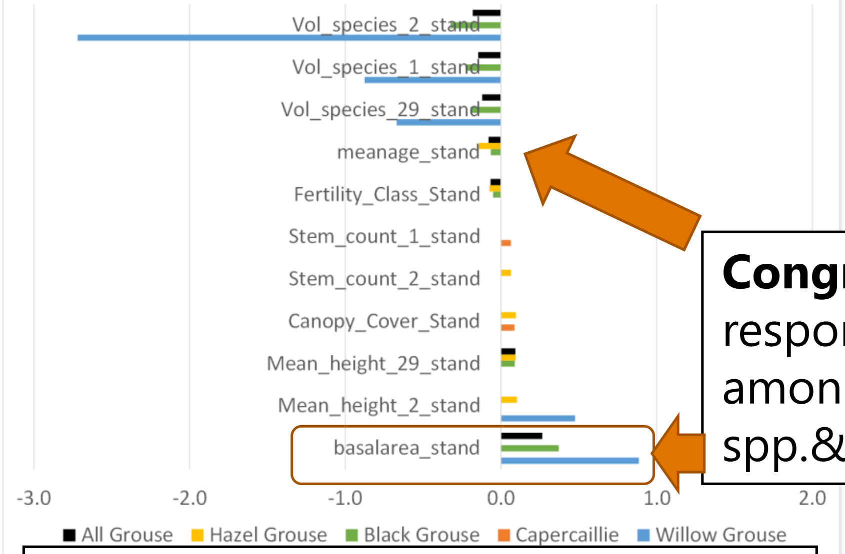
- The accuracy values (AUC) were different among species but similar across spatial scales
- Sampling effort and regional density (D) already explained well grouse occupancy patterns



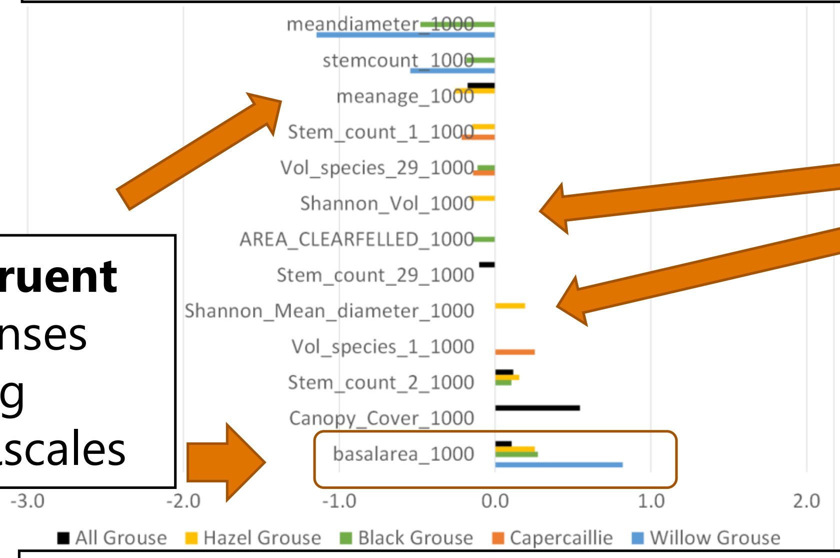


Results: Effects of significant forest predictors included in GAMMs on grouse occupancy

Average N. Stand predictors = 5.4



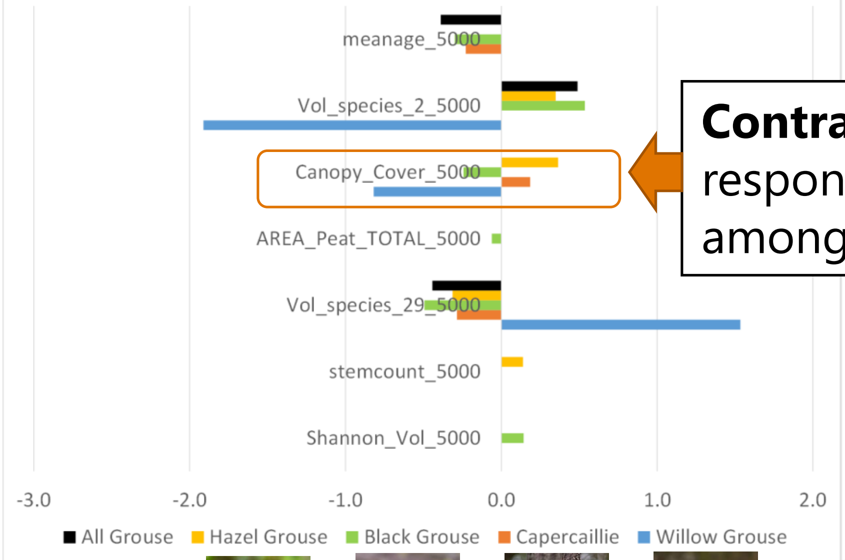
Average N. 1-km predictors = 4.6



Congruent responses among spp.&scales

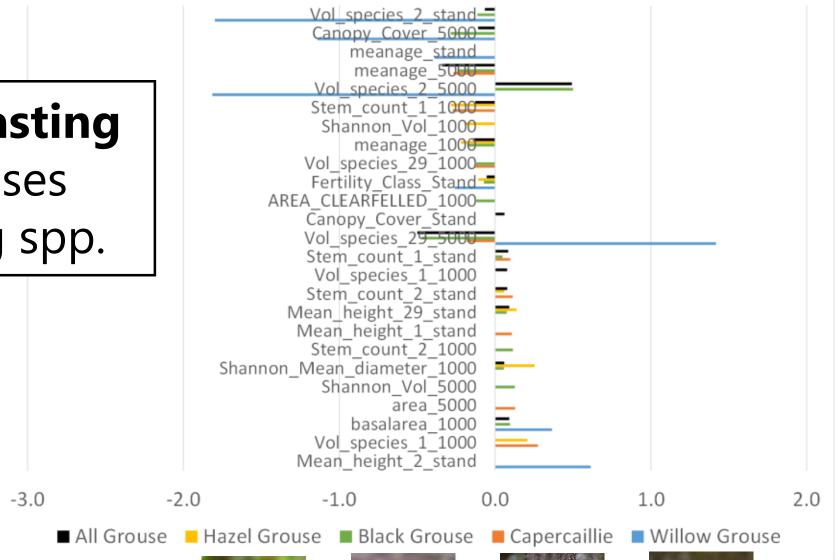
Structural variables included more at stand scale while **Diversity variables** (=Shannon) only at 1-km and 5-km scale

Average N. 5-km predictors = 3.4



Contrasting responses among spp.

Average N. Multi-grain predictors =11.2

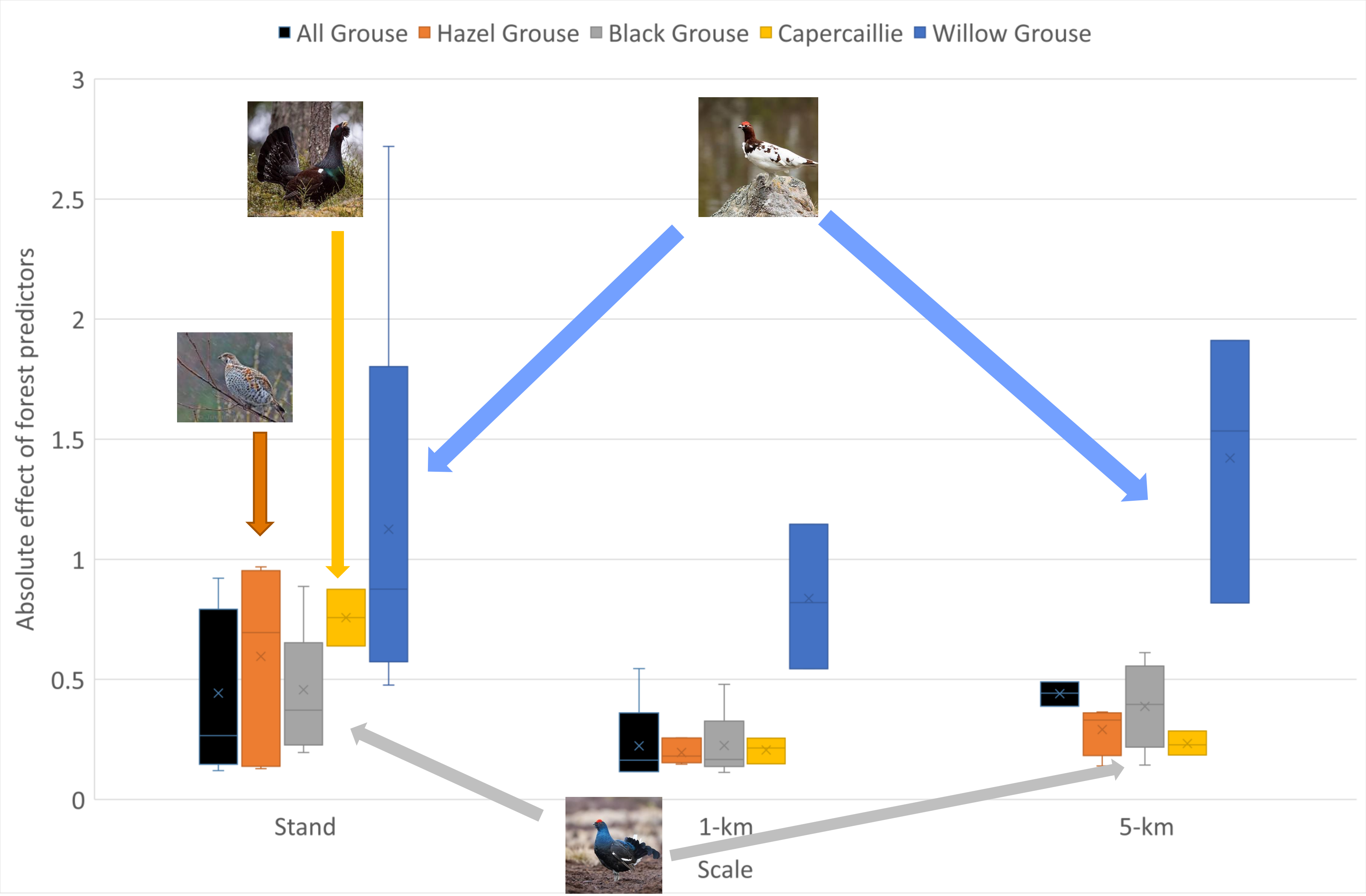


More predictors at stand scale in **multi-grain**:

Average % predictors:
Stand =41%
1-km = 33%
5-km = 26%

Results: Range of the absolute effect of the forest predictors

The effect of forest variable on grouse occupancy varies with scale and species



Conclusions:

(Q1) Does the spatial scale affect the accuracy of the grouse habitat models?

No, similar AUC values among scales but stand models had a larger number of predictors because less heterogeneity at 1-km and 5-km scale due to characteristics of Finnish forest production landscape.

(Q2) Is there an optimal spatial scale for modelling grouse occupancy?

No, different grouse species exhibit varying optimal spatial scales for occupancy prediction.

Stand scale (forest dwellers)

Open bog species

Stand & 5-km

5-km

(Q3) Are there common predictors explaining occupancy for all grouse spp. at different scales?

Yes, few common forest predictors related to multi-layered vegetation (positive effect of high canopy cover for forest dwellers, negative for open habitat spp.), suitable thickets (i.e. high basal area) and early successional forest (low forest age).

(Q4) Do habitat structure and composition affect occupancy differently at different scales?

Yes, forest structure consistently more influential than composition in predicting occupancy patterns.

Implications for management:

- Modeling grouse occupancy at different spatial scales can inform forest managers about the scale at which game-friendly management is most effective.
- The importance of the forest structure at the stand scale suggests that management decisions of single forest owner have direct impact for grouse presence.
- When managing grouse brood habitats, attention should be given to maintaining a multi-layered forest embedding both protective canopy cover and a good understory cover.
- Grouse species have their peculiar habitat preferences which should be considered when managing forests for different uses.
- To enable the benefits of multi-layered landscapes, forestry in private lands would need to be planned in agreement with multiple forest owners.




Thanks to the contribution of researchers involved in Luke thematic project INSPRICH (Indicators for species richness and biodiversity over ecosystem borders)

Adriano Mazziotta

Andreas Lindén

Kyle Eyvindson

Simone Bianchi

Annika Kangas

Marcus Melin

Leena Ruha

Jukka Forsman

Luke

UNITE FOREST-HUMAN-MACHINE INTERPLAY

FLAGSHIP PROGRAMME

NMBU Norwegian University of Life Sciences

Thank you for listening! Questions?

Luke