FORLAND

Sustainable agricultural landscapes – benefits and challenges of spatial optimization analyses for the case of Brandenburg, Germany

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Spatial optimization of agricultural land use in BB

Motivation:

- Decline of farmland biodiversity in the last decades
- Relevance of landscape elements (hedges) for biodiversity; Targeted minimum area
- Farmland birds respond very differently to the planting of hedges.
- Trade-off between agricultural production an biodiversity

Source: https://commons.wikimedia.org/wiki/File:Hedges_on_Stipadon_Farm_-_geograph.org.uk_-_1100291.jpg

Research Question:

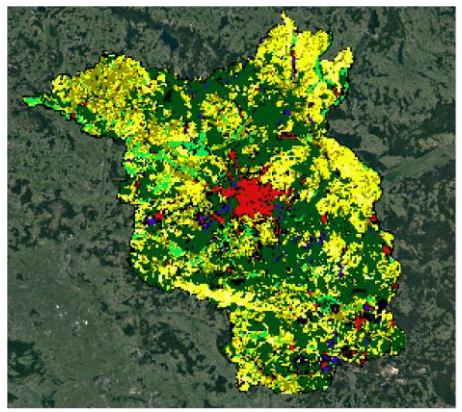
- What is the potential of improvement in biodiversity and agricultural production compared to the current situation?
- Where would measures like planting of hedges be most beneficial?

Spatial optimization of agricultural land use in BB

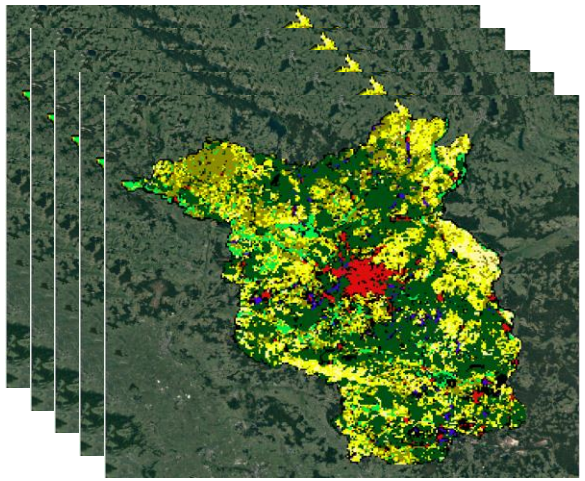
What is spatial optimization? (*Cao, K. 2017)*

- Decision variables
- Objectives
- Constraints

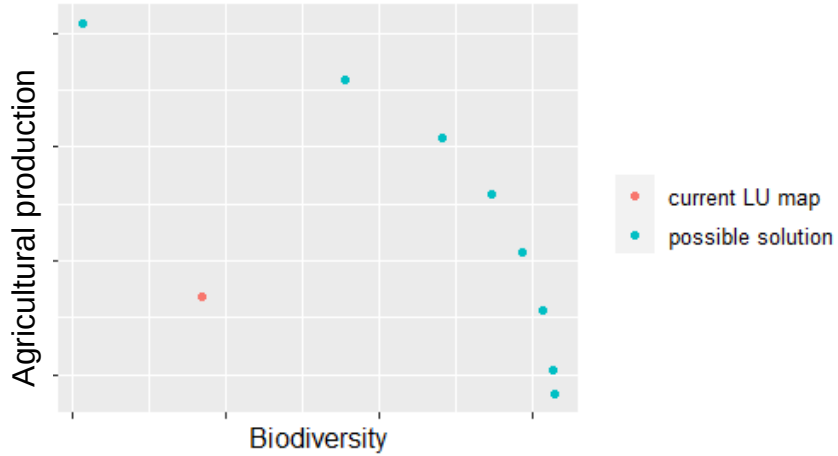
(A) Current situation



(B) Optimal solutions in space



(C) Optimized situation in objective space



Gurobi Optimization. (2021). *Gurobi optimizer reference manual*. https://www.gurobi.com

Spatial optimization of agricultural land use in BB

What is optimized (decision variable):

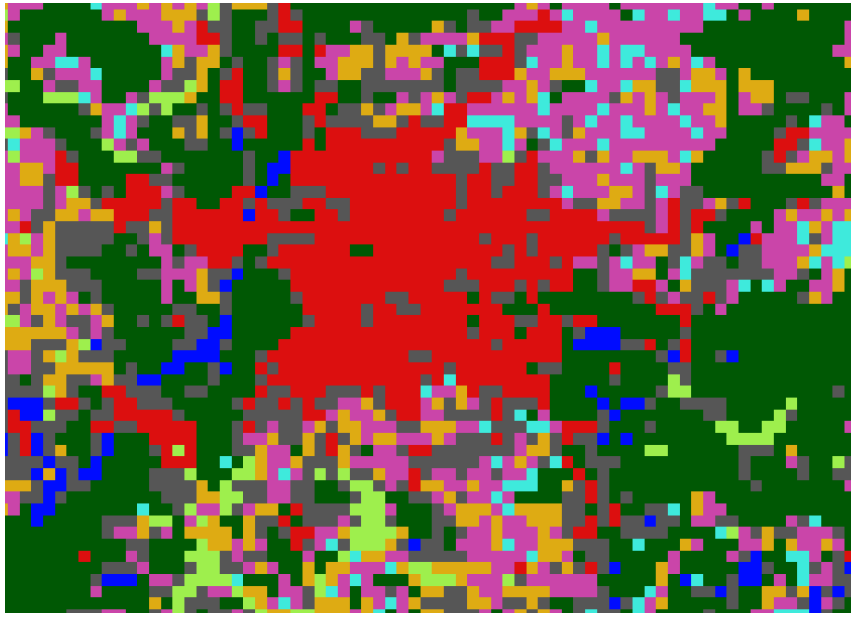
- The amount of small woody features (SWF) within a km², represented by three classes: small amount (<1%), moderate (<5%) and high (>5%) amount of SWF

Measures to be maximized (Objectives):

- Agricultural production
- Farmland biodiversity

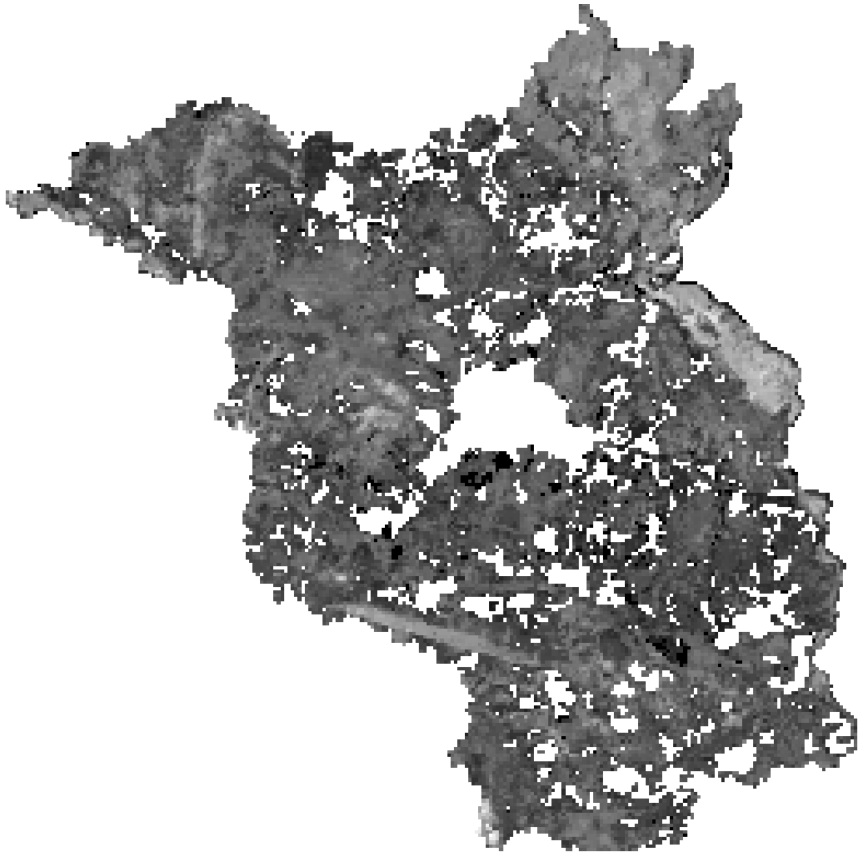
What is not possible (constraints):

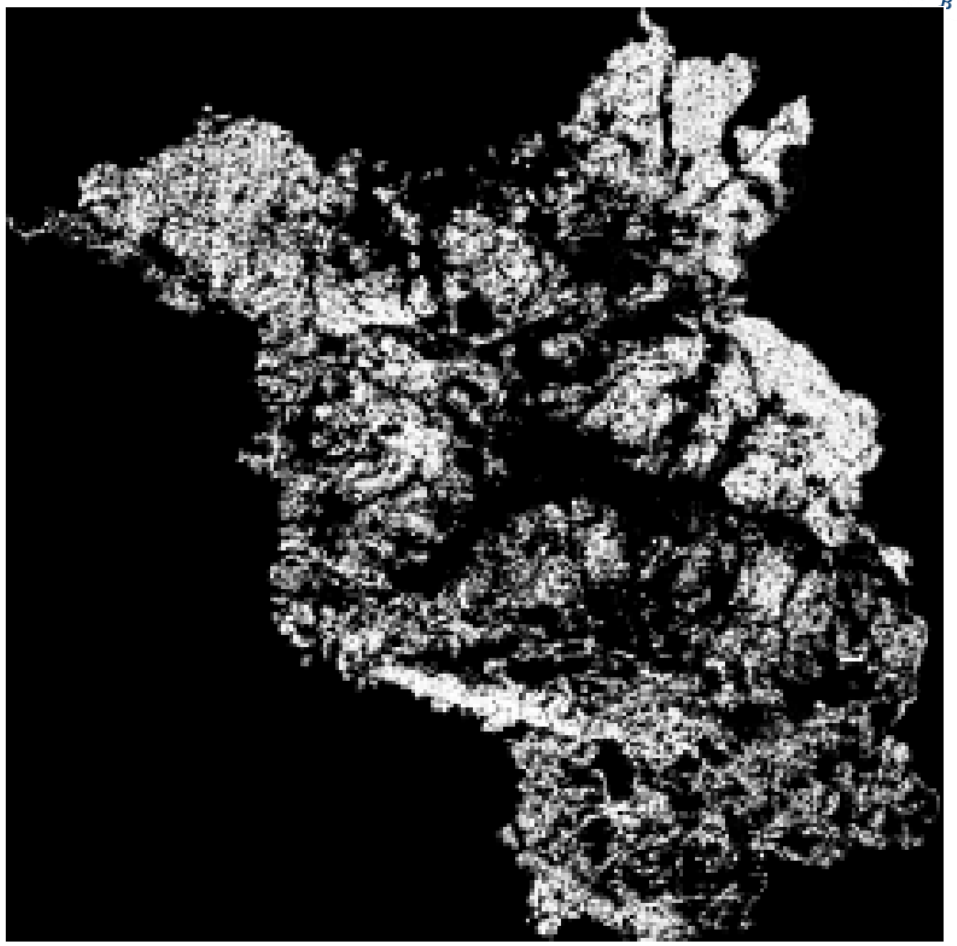
- Farmland classes cannot be converted to any other land use and vice versa
- No single bird species can decline by more than X%



LU/LC map of Berlin and surroundings; The optimization works on a spatial resolution of 1x1km

Objective function agricultural production





Soil quality for agricultural purposes (Ackerzahl);

Share of agriculture in m² within km²

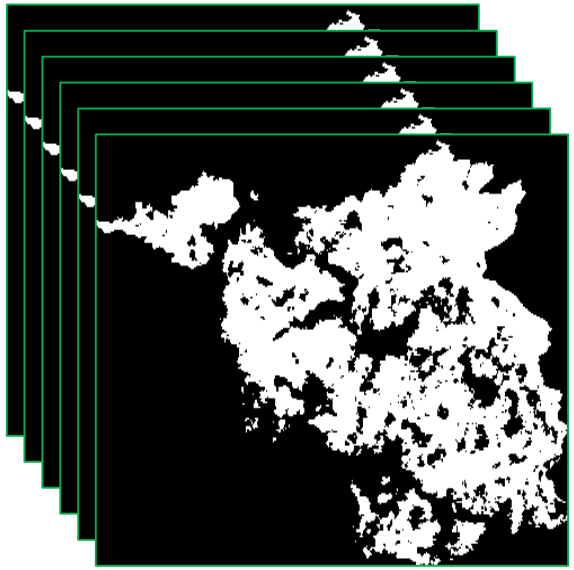
Objective function Biodiversity

Potential species distributions:

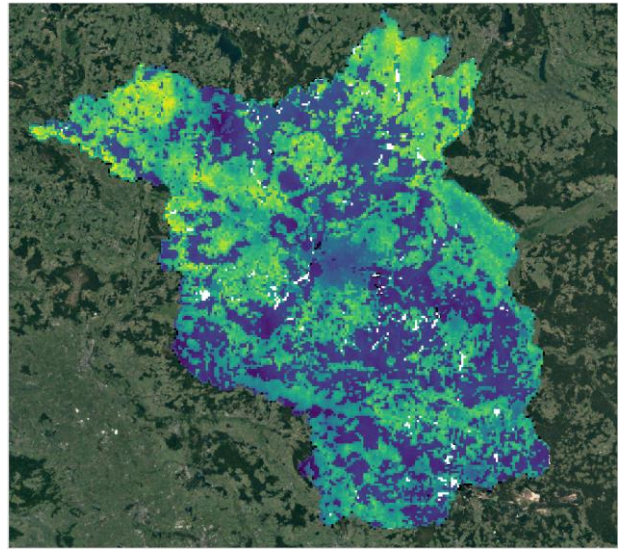
- Distribution should reflect potential distribution of bird species
- Wallace: reproducible modeling of species niches and distributions (*Kass et al. 2018)*. Modelling based on Maxent

Relative abundance:

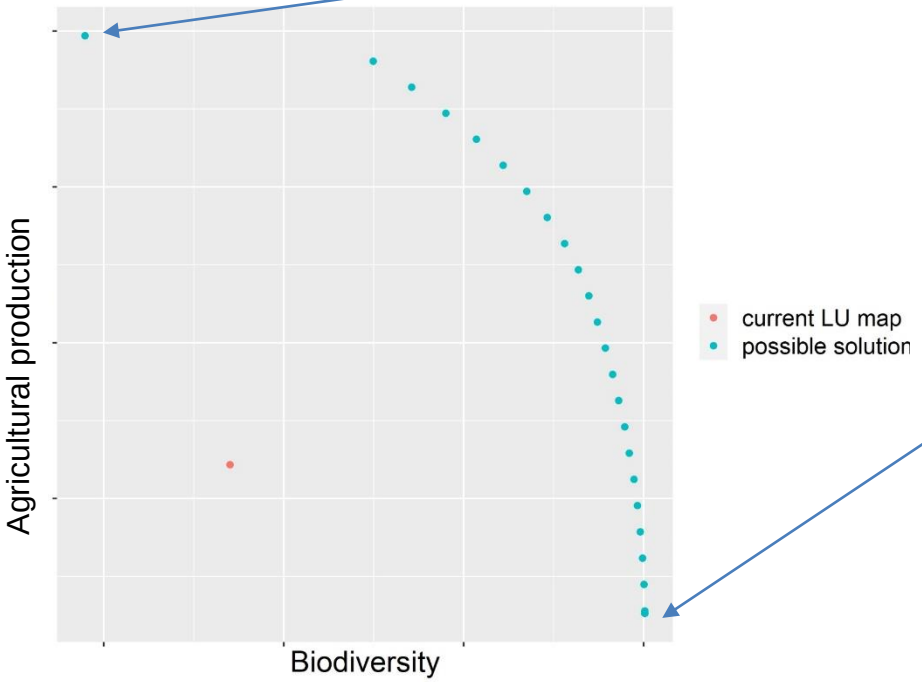
- Relative abundance is averaged for each species for each land system with 1 representing the highest abundance across land systems

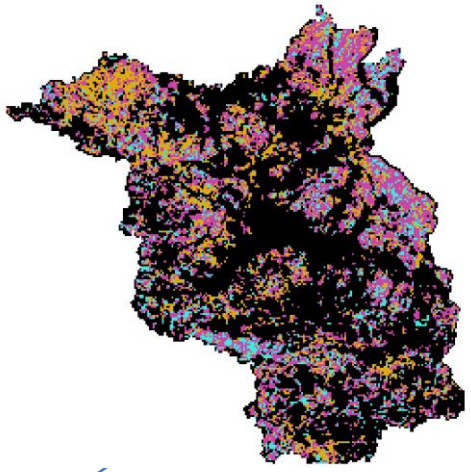


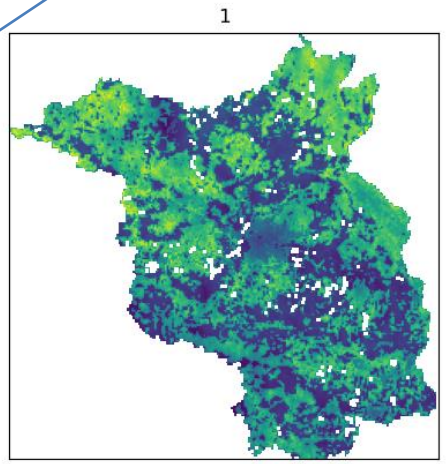
Species	Land system class	relative abundance
Grauammer	few hedges	0.54347826
Grauammer	moderate hedges	0.95108696
Grauammer	high hedges	1.00000000
Grauammer	forest	0.12212995
Grauammer	urban	0.06793478
Grauammer	grassland	0.79580745
Grauammer	other	0.35408432
Feldlerche	few hedges	1.00000000
Feldlerche	moderate hedges	0.75243902
Feldlerche	high hedges	0.52039024
Feldlerche	forest	0.14886270
Feldlerche	urban	0.01707317
Feldlerche	grassland	0.85365854
Feldlerche	other	0.18521803

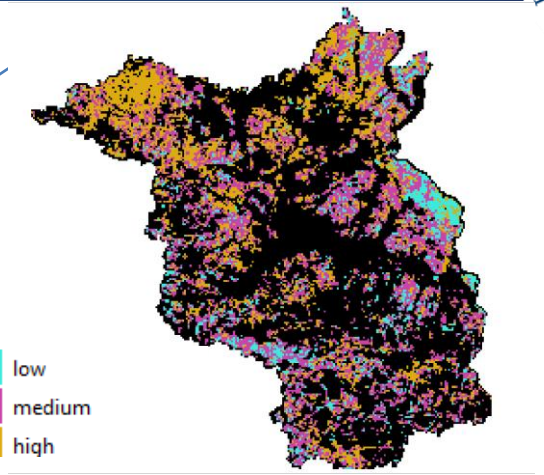


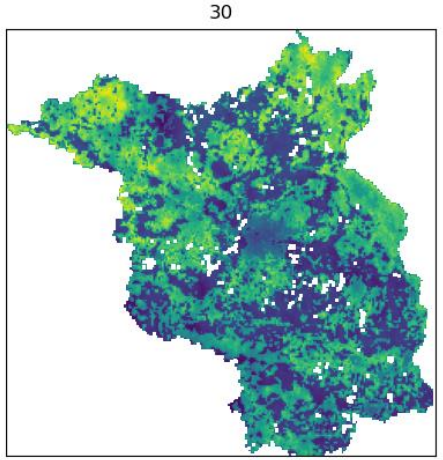
Results











Pareto frontier with current land use configuration (solution in objective space)

Top: LU/LC configuration

Bottom: Biodiversity for Max agriculuture solutution

Top: LU/LC configuration

Bottom: Biodiversity for Max biodiversity solutution

Benefits, limitations and next steps

Benefits:

- What would happen if and where to put things?
- Knowing trade-offs is beneficial for decision makers

Challenges and Limitations:

- Only two objectives at the moment
- Optimization problems with many decision variables can quickly get hard to solve for the solver
- Formulation of spatial optimization problems can be challenging

Next steps/ open questions:

- Improve calculation of agricultural production
- How to go from results to policy advice
- Spatial scale of the analysis (landscape, farm, regional, etc.)

Main references

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