

Socially optimal allocation of wind turbines under conflicting policy objectives

Combining ecological-economic modelling and choice experiments in a case study in Germany (BMBF Project FlaechEn)



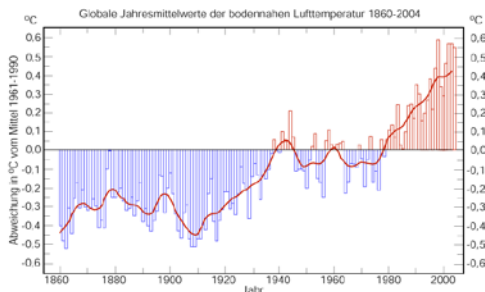
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Karin Johst, Jürgen Meyerhoff, Jan Monsees,
Cornelia Ohl

Wind power in the focus of conflicting environmental policy goals

Climate and energy policy



Depletion of fossil fuels, energy security



CO₂ emissions
global warming

Wind power



positive

negativ

Sustainable land use



Land consumption
landscape quality



Nature conservation
(birds, bats)

FlächEn: Strategies for sustainable land use in the context of wind power generation

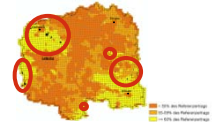
Funding

BMBF (Fkz.01UN0601A,B) – 1.2.2007 bis 31.6.2010 –
Förderschwerpunkt “Wirtschaftswissenschaften für Nachhaltigkeit”



Project partners

A: UFZ Leipzig (Departments: ÖKON, ÖSA, UPR, ENVINF)
B: TU Berlin (Fachgebiet Vergleichende Landschaftsökonomie)
7 partners from practice



Objectives

Quantification of external effects of wind power production
Recommendations for an optimal use of landscapes for wind power production
Contribution to the evaluation of regional planning processes



Methods

GIS-based ecological-economic modelling
Choice experiments
Jurisprudential analysis



Optimal allocation of wind turbines

Alleviate conflict between policy objective by appropriate spatial allocation of wind turbines

Decision problem:

Produce a given amount of wind power at minimum social cost

Social cost here is the sum of

- Production costs
- External costs

Decision variables:

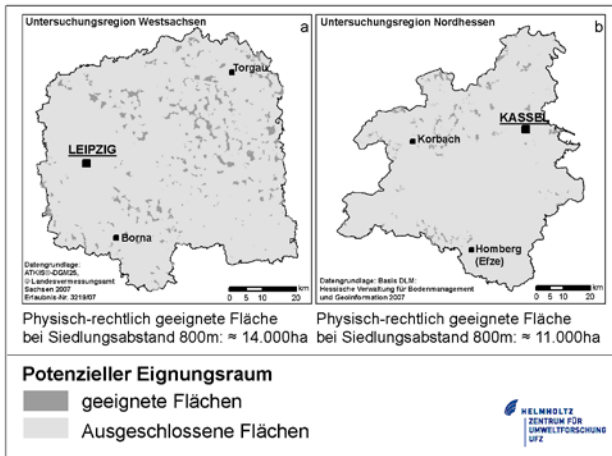
For each potential site $i=1, \dots, N$ decide whether a wind turbine is installed, and if yes, whether it should be a large (200m), medium (150m) or small (120m) one

1. Identify potential sites

a. Physical constraints: open land

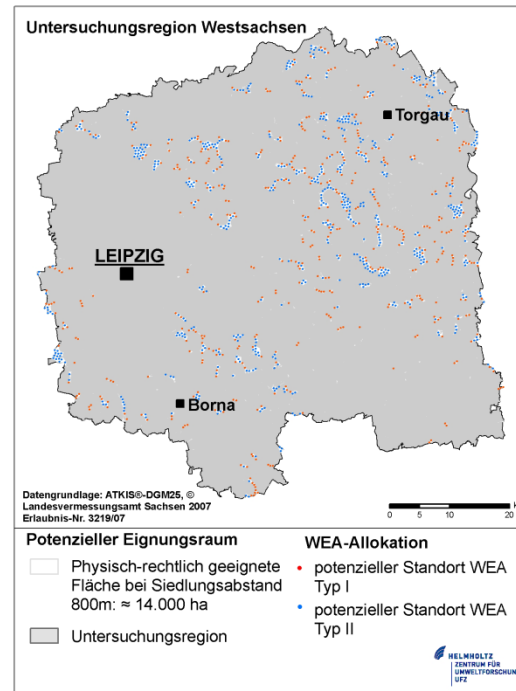
b. Legal constraints:

Protection of water and biodiversity (e.g., no WT in nature protection areas)
Protection of infrastructure (e.g., minimum distances to motorways)
Protection of human health (e.g., maximum bounds on sound immissions in residential areas => minimum distances of WT to settlements)



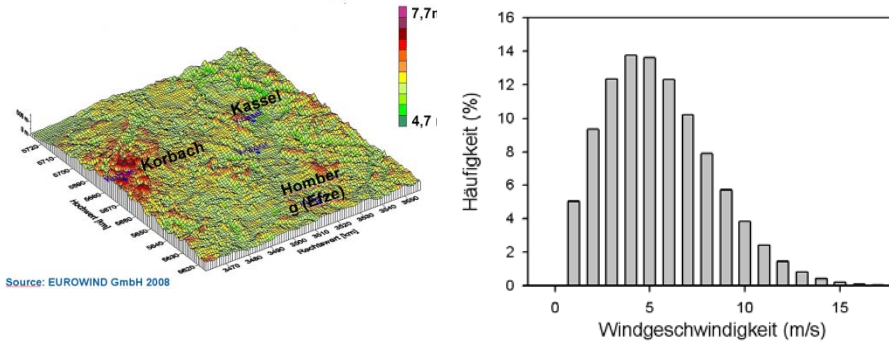
c. Technical constraints: minimum distances between WT

=> grid of potential sites



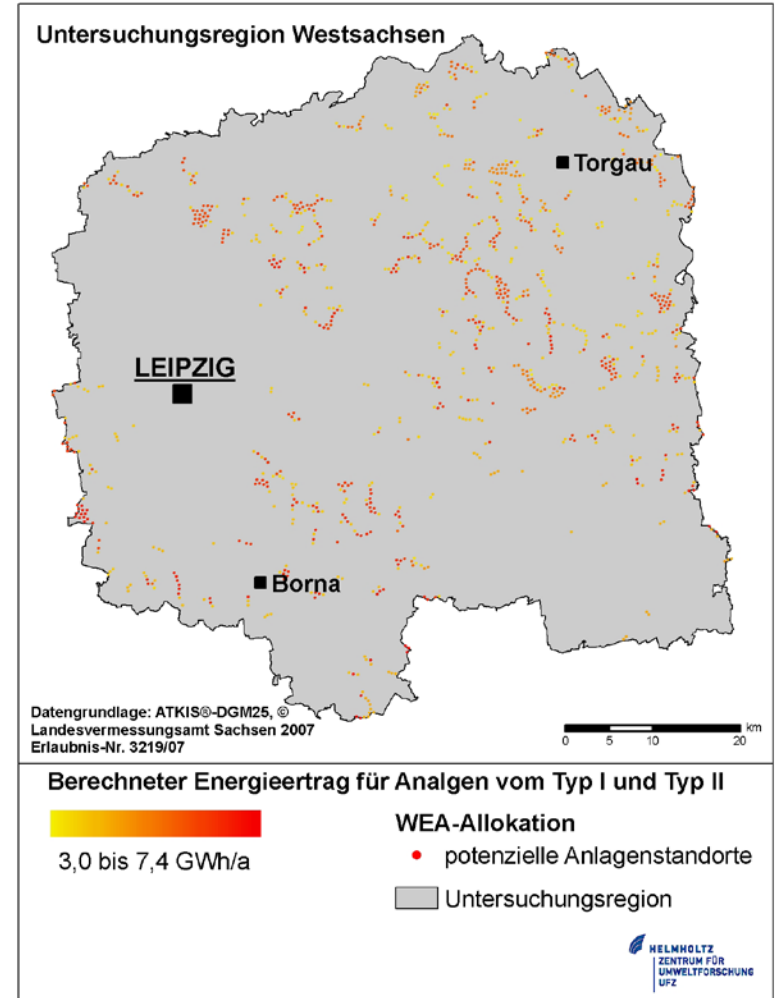
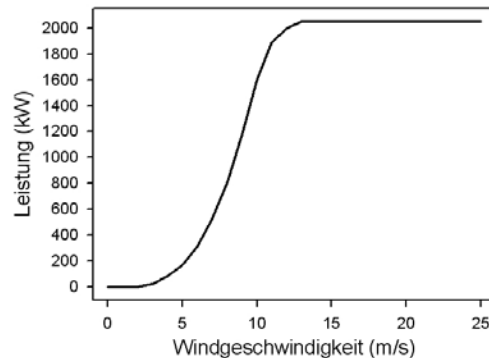
2. Assess sites with regard to wind power output

Wind speed distributions
(1x1 km² grid, three altitude levels)



⇒ Annual energy output for each potential site

Power curve of wind turbine
(power as function of wind speed)



3. Assess production costs and benefits for each site

Costs in 1000€

Annual costs discounted at 3% per year

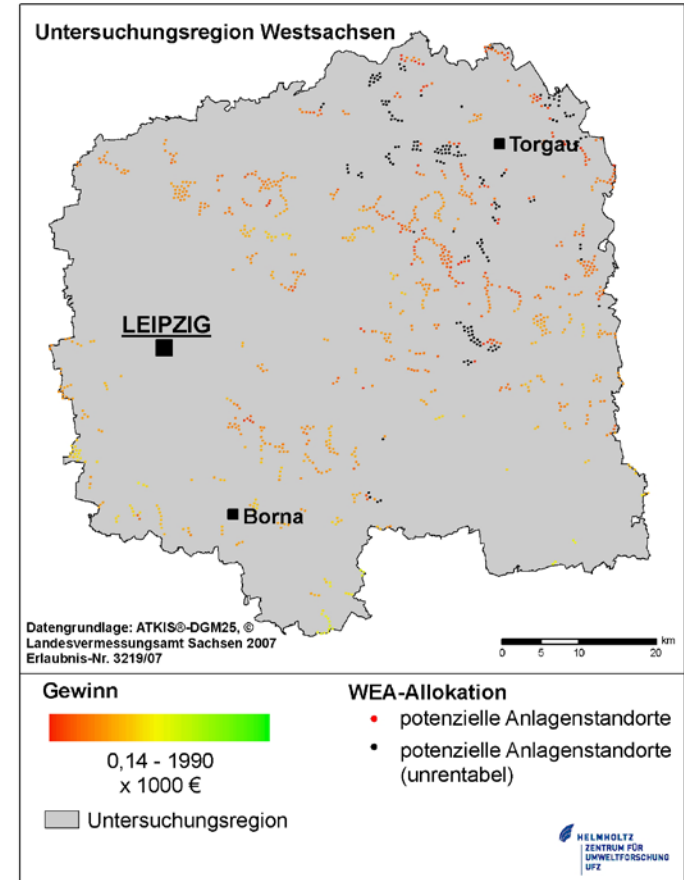
WT Type	Sales price	Added infrastructure costs	Total investment cost	Annual operating costs
Small	2,407	240	2,648	132
Medium	3,172	317	3,489	174
Large	12,000	1,200	13,200	660

Benefits from Renewable Energy Act (EEG)

5.02 cents/kWh basic tariff

9.7 cents/kWh initial tariff (paid for x months;
x decreases with increasing energy output

Economic profits



4. Assess external effects

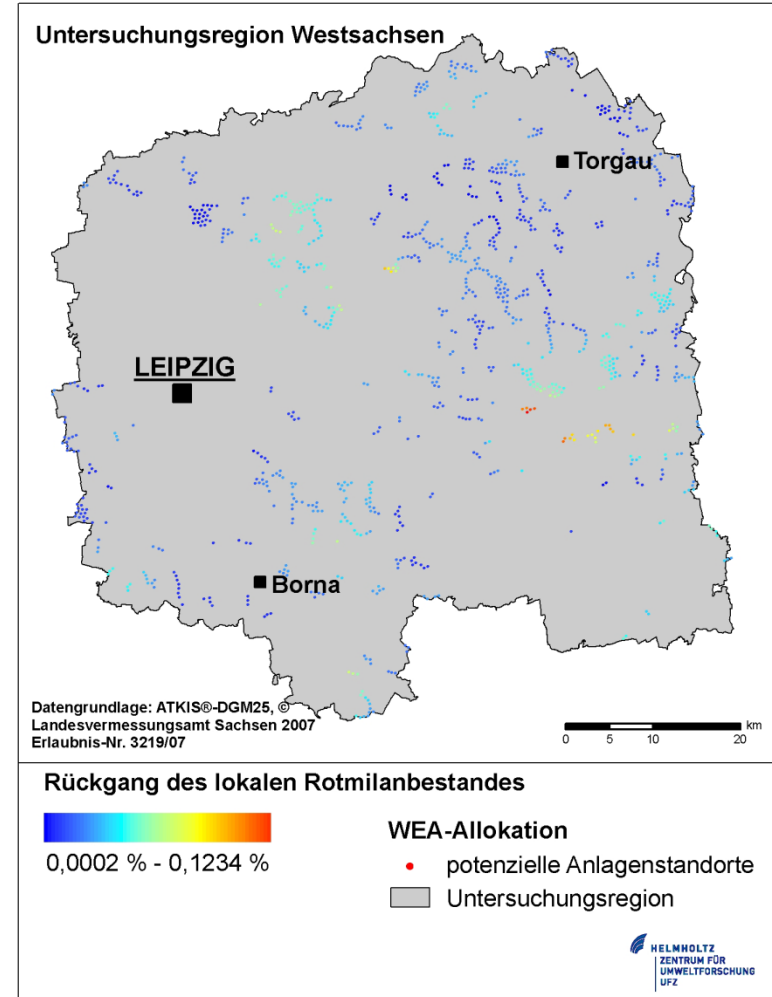
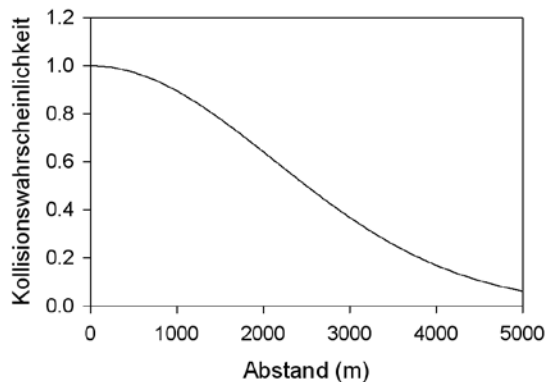
Relevant attributes after interviews with focus groups

- a. Size of wind farms
- b. Maximum size of wind turbines
- c. Minimum distance of WT to settlements
- d. Decline rate of red kite population

- (a) and (b) not significant in later analysis
- (c) „trivial“
- (d) model impact of WT on red kite

Total impact on red kite population

Collision risk vs. distance between nest and WT



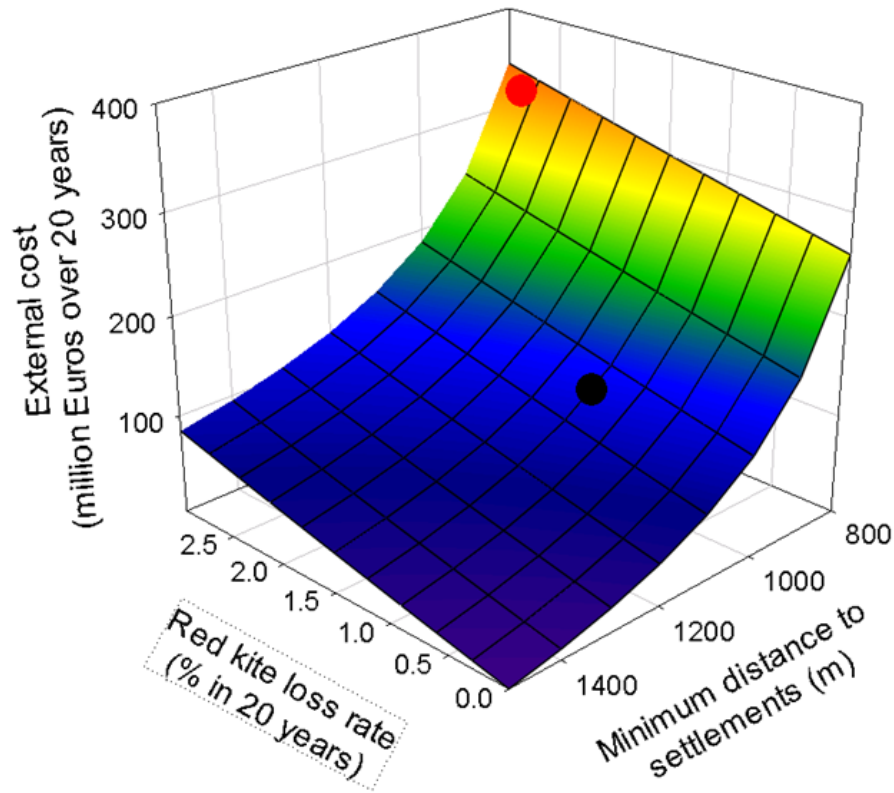
5. Value external effects

Choice experiments

Wind power in Westsachsen until 2020			
	Programme A	Programme B	Programme C
Size of wind farms	large farms	small farms	large farms
Maximum height of turbines	200 metres	110 metres	110 metres
Red kite population loss rate	10%	5%	10%
Minimum distance to settlements	750 metres	1100 metres	1500 metres
Monthly surcharge to power bill	€ 0	€ 6,-	€ 1,-
I choose	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

5. Value external effects

Fit non-linear function to significant mWTP
⇒ External cost function



6. Optimisation

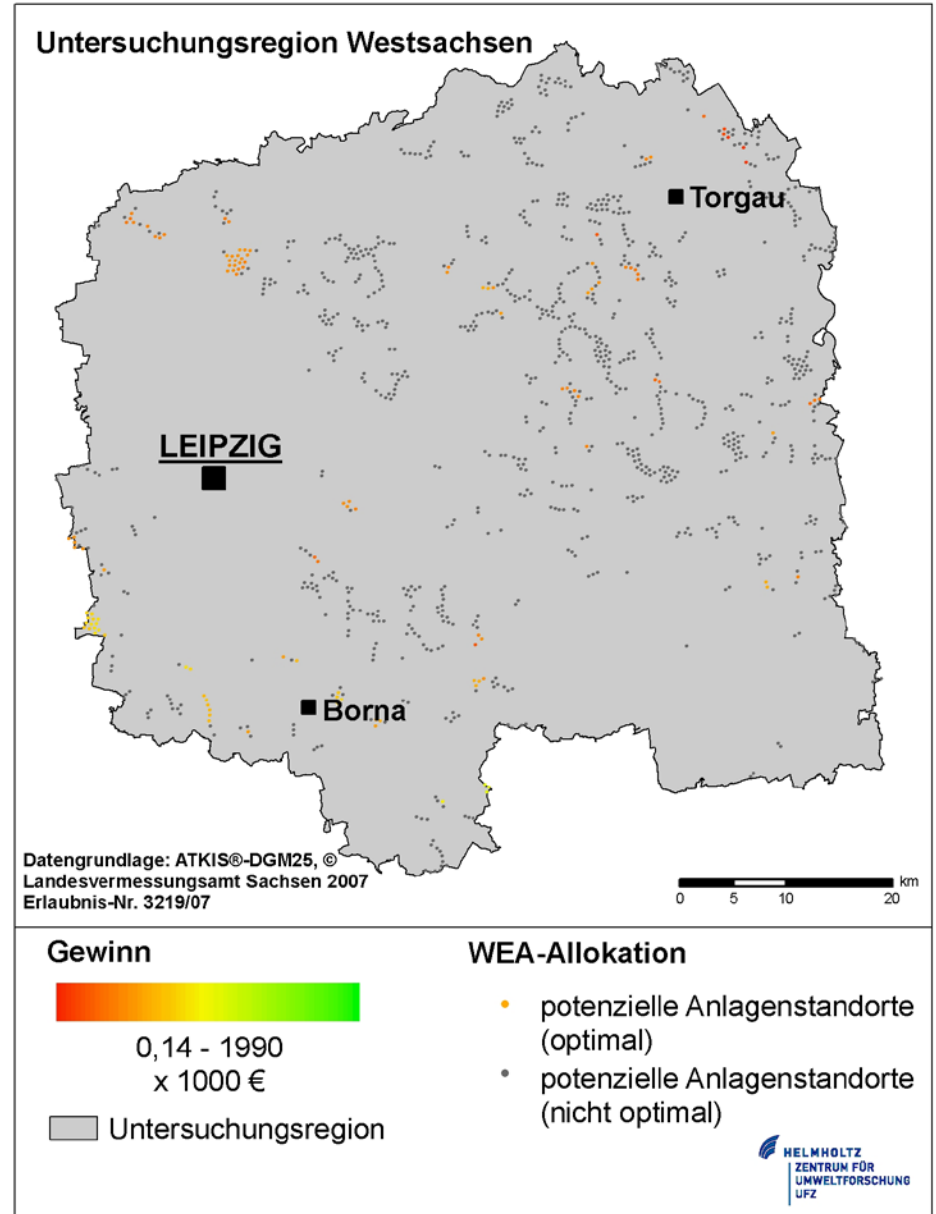
Allocate WT to sites so that 690 GWh are produced per year at minimum social cost (social cost = sum of production cost and external cost)

⇒

Optimal min. distance to settlements:
1025 m

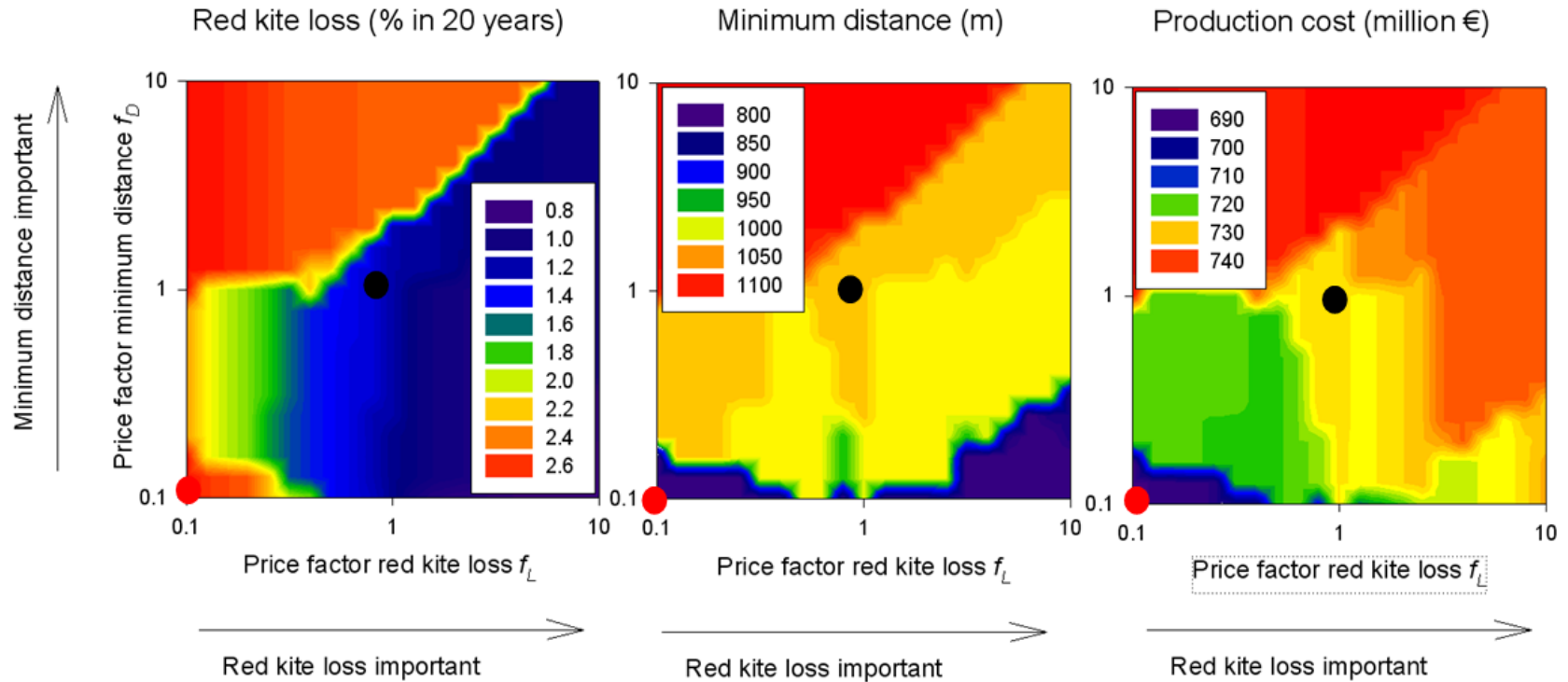
Optimal loss rate of red kites:
1.2% in 20 years

Optimal production cost:
730 M€ over 20 years



Sensitivity analysis

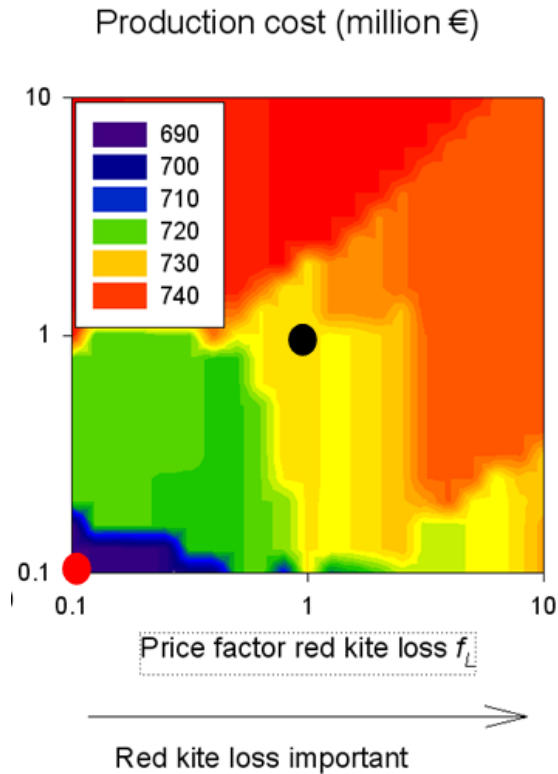
A: Vary marginal willingness to pay



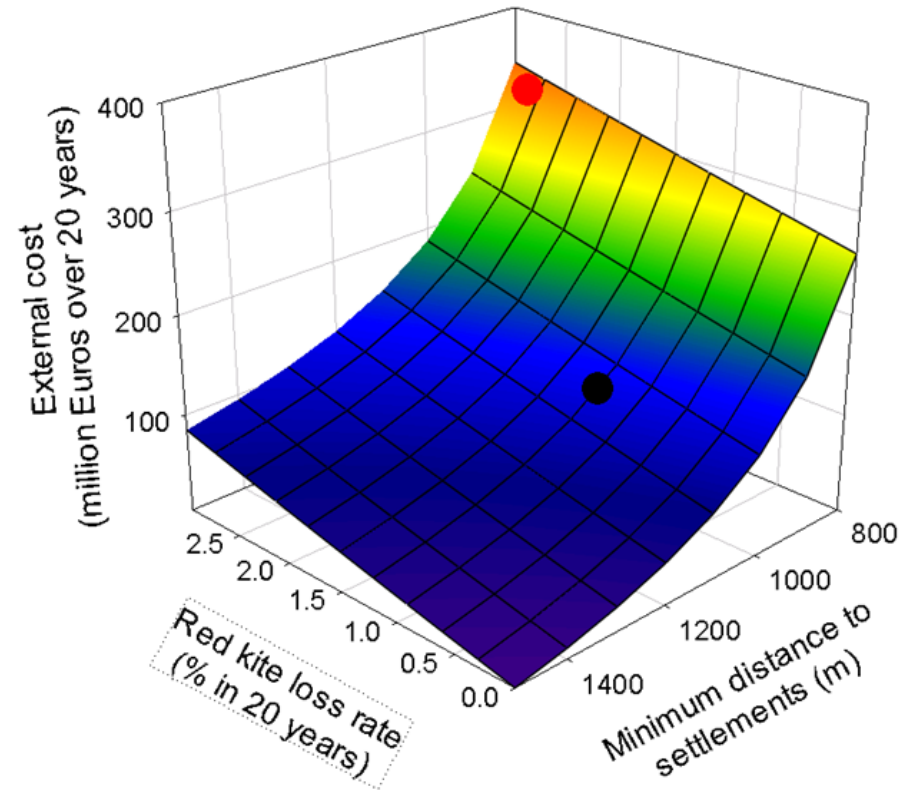
Increasing mWTP for avoiding an externality

- reduces the associated externality
- increases the other externality
- increases production cost

Welfare gain associated with consideration of externalities



Increase of production cost
by 40 M€



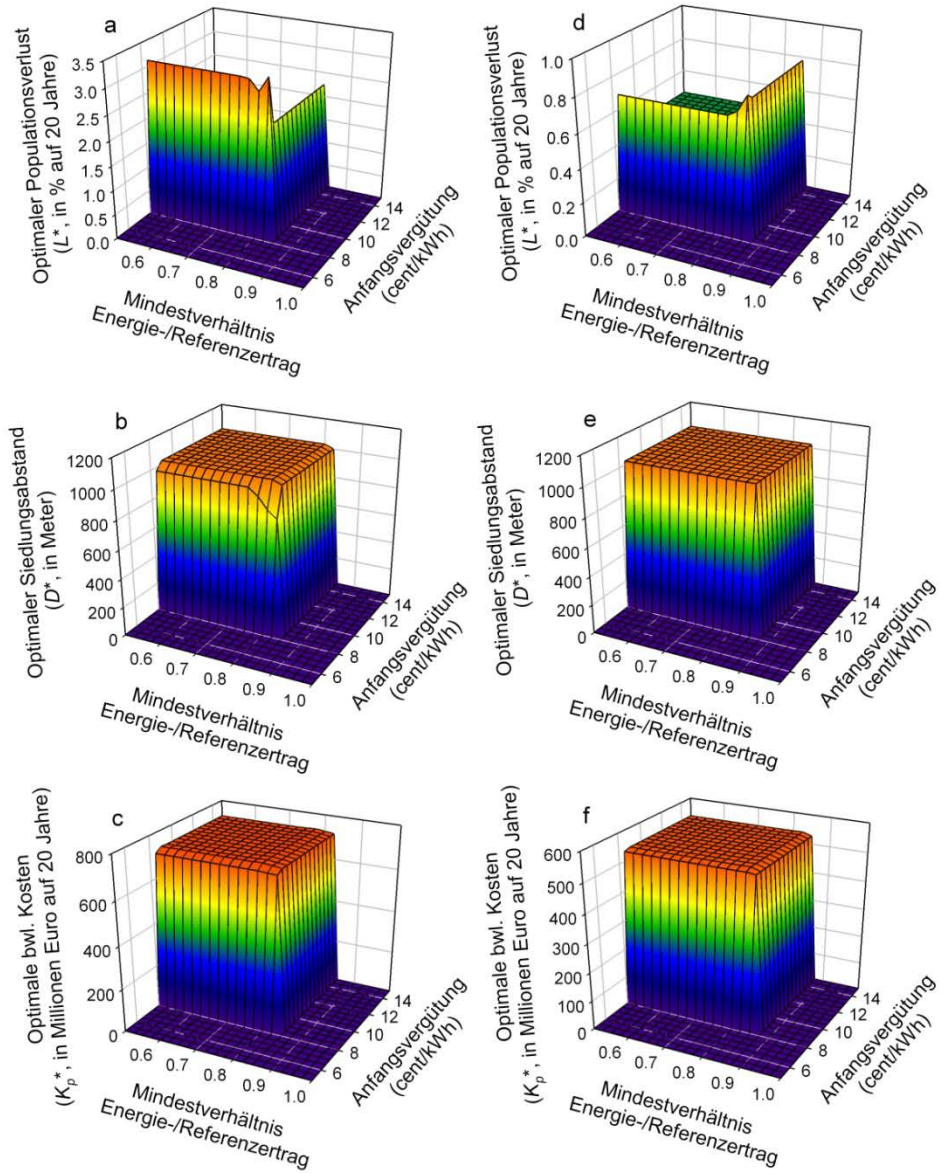
Decrease of external cost
by 210 M€

Sensitivity analysis B: Vary tariffs of Renewable Energy Act

Decreasing tariffs

- decreases production costs
- increases external costs

If decrease to strong energy target
cannot be met



Conclusions

Welfare-optimal use of landscapes (e.g. for wind power production)

Spatially explicit analysis

Integration of natural and social science knowledge (ecological-economic modelling)

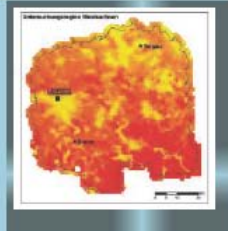
Integration of societal preferences

Trade-offs between production and external costs

Consideration of externalities increases social welfare

Design of feed-in tariffs affects both production and external costs

Ein Verfahren zur optimalen räumlichen Allokation von Windenergieanlagen



Thank you for your attention!

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Jürgen Meyerhoff und Jan Monsees

metropolis