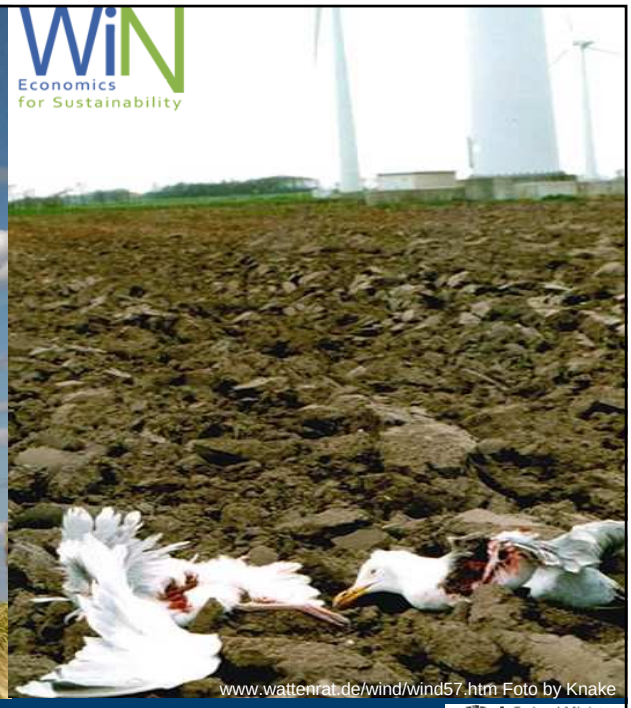

www.wattenrat.de/wind/wind57.htm Foto by Knake

How to cope with externalities of wind power development? - Combining *Ecological-Economic Modelling* and *Choice Experiments* A German Case Study

Cornelia Ohl (Economics) and Marcus Eichhorn (Ecological Systems Analysis)

WiN Economics for Sustainability

Federal Ministry of Education and Research

fona Forschung für Nachhaltigkeit

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Overview

The Project
Partners and Goals

Background
Energy Goals of Climate Policy
Externalities of Wind Power Development

The Modelling Framework
Study Region - West Saxony
GIS-based Ecological-Economic Modelling
Choice Experiments

Results and Discussion

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Project partners and Duration

- **Research Team**
  - **Helmholtz Centre for Environmental Research - UFZ, Leipzig**
    Economics (Lead), **Ecological Systems Analysis**,
    Environmental and Planning Law, Environmental Informatics
  - **Berlin Institute of Technology (TU Berlin)**
    Dep. of Environmental and Land Economics

- **External Monitoring Group**

  BWE – German WindEnergy Association
  CMI – Carbon Management International
  NABU – Nature and Biodiversity Conservation Union
  MASLATON – Attorneys-at-law
  MILAN – Middle German office partnership on nature protection and landscape conservation
  Regional Planning Authorities – West Saxony, Northern Hesse

- **Duration**: **3 Years** (Start: 1.2.2007)

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Goals

- Assessing landscape related impacts of wind power development with the help of **Choice Experiments** and **Ecological-Economic Modelling Framework.**
- **Evaluation of Planning Procedures on the Regional Level** regarding the identification of sites for wind power development.
- Recommendations for **Optimization and Re-Allocation** of land use options for wind energy supply.
- **Visualisation** of alternative land use options in the **landscape theatre** (TESSIN) at UFZ.

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Background – Wind power in Germany

- Wind power is the most cost efficient renewable energy source today.
- 2007 wind power contributed to reduce CO2 in the electricity sector in Germany by roughly 45%.
- German wind power quota (2006: 5%) is expected to double until 2030 => **10%**.

Wind power is to contribute significantly to reduce CO_2 emissions and to accomplish German climate policy goals in future!

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Externalities of Wind Power Development

Federal Emission Control Acts (BImSchG, TA Noise)

Humans

- sound emissions
- shadow and light emissions
- visual impact on the landscape

Federal Nature Conservation Acts (e.g. Natura2000, SPA)

Environment

- loss of habitat
- disturbance and displacement of birds
- increased mortality of certain species

2 Study Regions

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Modelling Framework - Study regions

Northern Hesse

West Saxony

Residents (2005): 1Mio

Land area: 4.400km²

Red Kite (*Milvus milvus*)

Population worldwide: max. 25.000 couples

In Germany: roughly 50% (with 2/3 in Eastern Germany)

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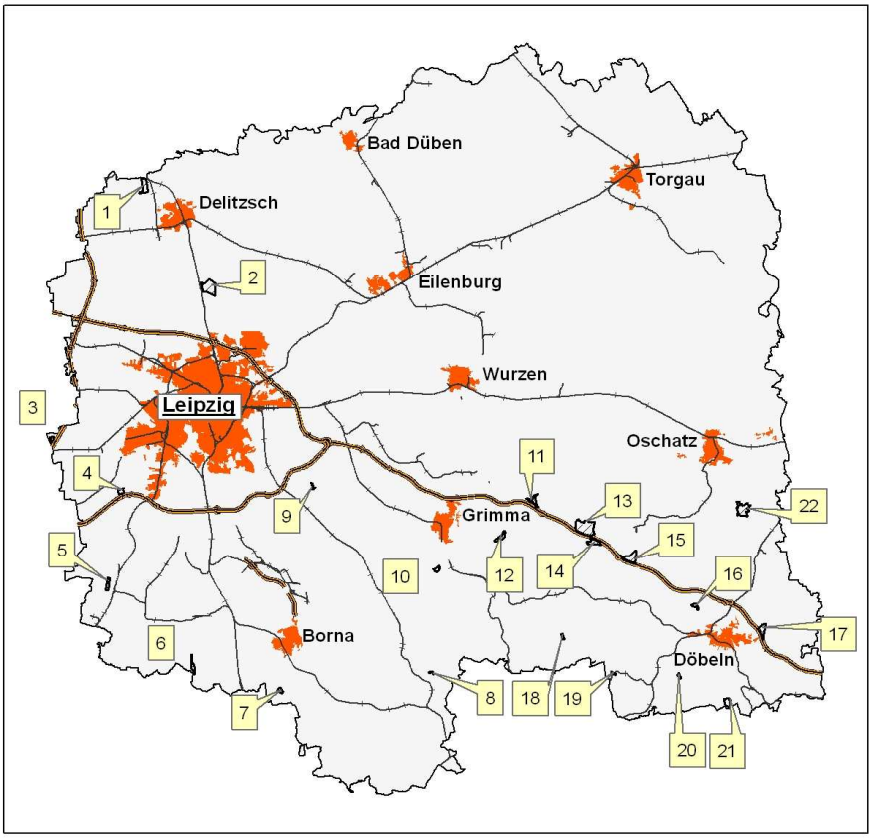
Wind Power Development Zones in West Saxony



Legend

Planning region West Saxony

Traffic infrastructure

National motorway

Railway

Built-up areas

for example, Leipzig, Torgau, Döbeln

Priority and suitability areas (VE areas) Wind power

Priority and suitability areas Wind power

Area no.	Area name	size in hectars
1	Zaasch	74
2	Rackwitz	161
3	Grosslehna	15
4	Knautnaundorf	22
5	Pegau	32
6	Hohendorf/Ramsdorf	34
7	Thräna	18
8	Tautenhain	5
9	Fuchshain	9
10	Großbardau	19
11	Silberberg	48
12	Schkortitz	41
13	Jeesewitz/Ablaß	240
14	Sitten	54
15	Bockelwitz	87
16	Großweitzschen	19
17	Mochau	63
18	Bockwitz	12
19	Hartha	8
20	Kaiserburg	9
21	Littdorf	46
22	Naundorf	129

Research Questions

Is there sufficient land area available at the regional level in order to accomplish energy and climate policy goals in Germany?

Is the land area efficiently provided from a welfare economic point of view?

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The Modelling Framework

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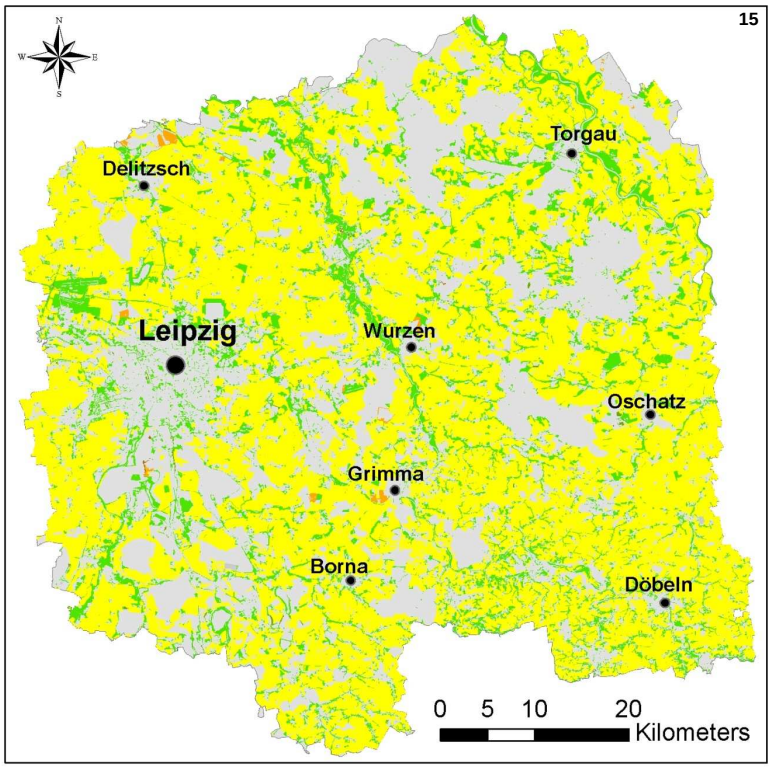
Modelling Framework

Planning Region West Saxony

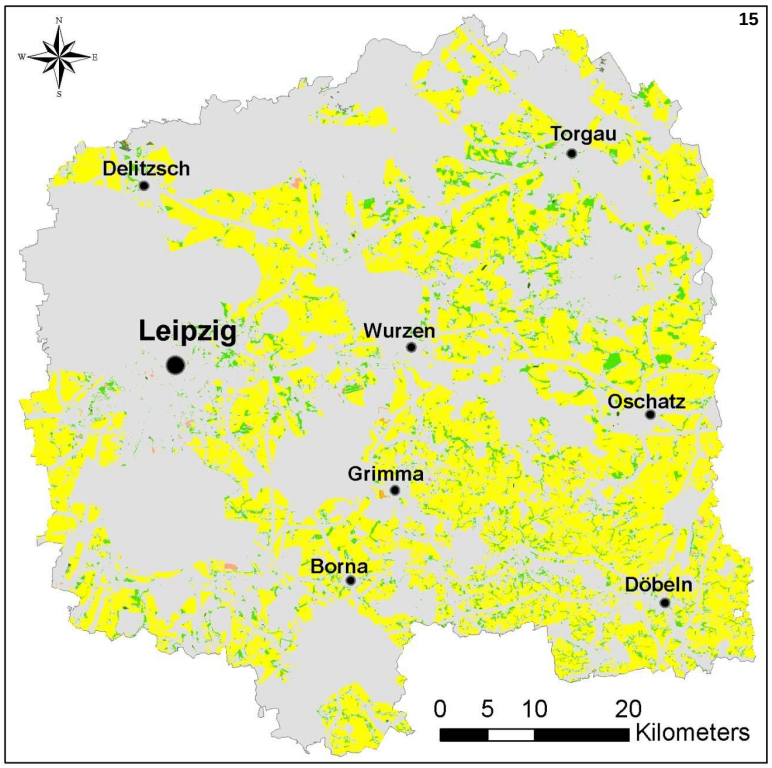


Search for potential wind turbine sites by exclusion of:

1. **physically unsuitable areas** (e.g. settlements, forests)

Modelling Framework

Planning Region West Saxony

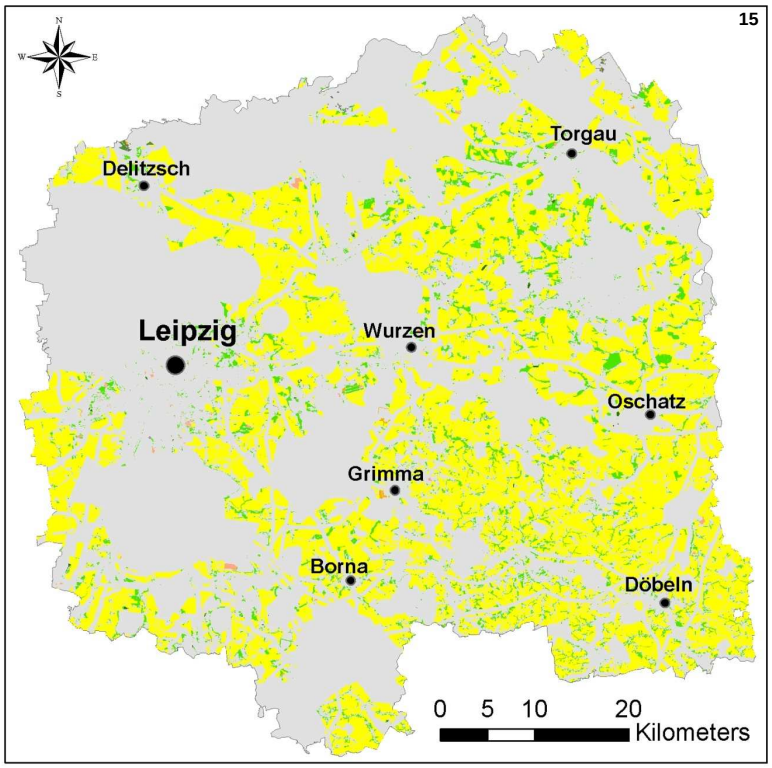


Search for potential wind turbine sites by exclusion of:

1. **physically unsuitable areas** (e.g. settlements, forests)
2. **legally restricted areas** (e.g. bird protection)

Modelling Framework

Planning Region West Saxony

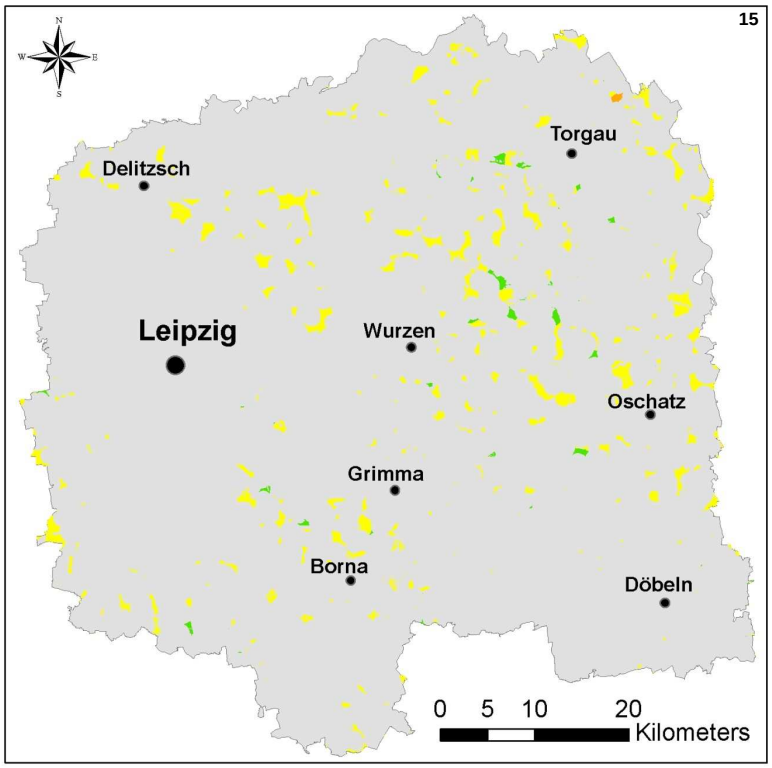


Search for potential wind turbine sites by exclusion of:

1. **physically unsuitable areas** (e.g. settlements, forests)
2. **legally restricted areas** (e.g. bird protection)
3. **buffer areas around settlements** (settlement distance 800m)

Modelling Framework

Planning Region West Saxony



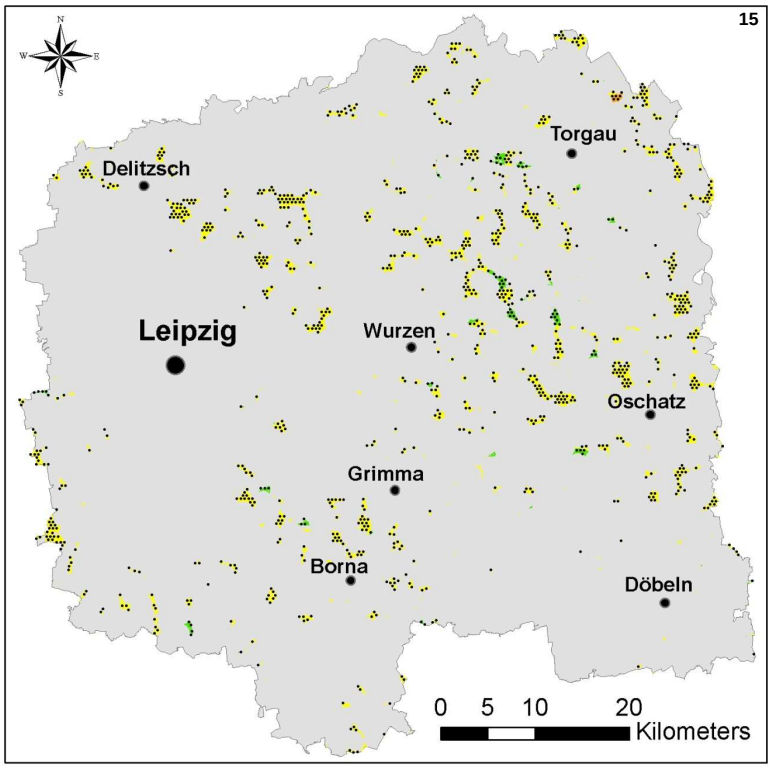
Residual area: about **145km²** (3% of total area)

How many wind turbines could be erected?

Monte – Carlo – Simulation

Modelling Framework

Planning Region West Saxony



Allocation pattern

- about 1000 potential wind turbines

Assessment of sites

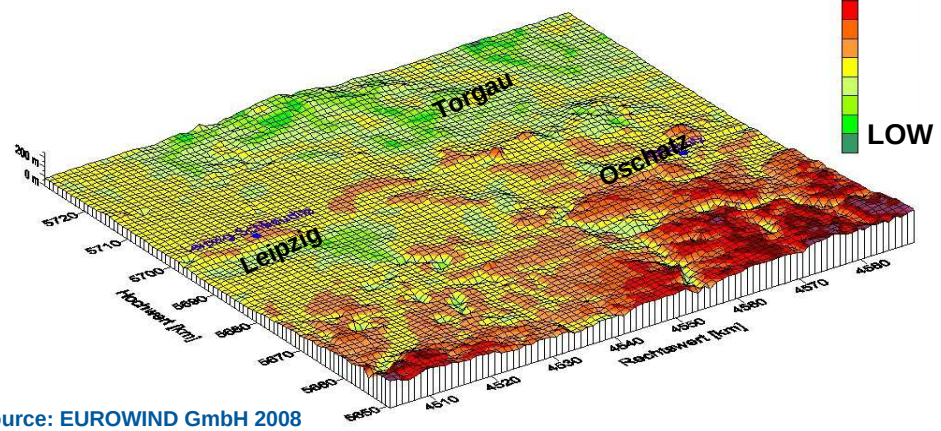
- energetic potential
- ecological impact

Modelling Framework – energetic criteria

Wind energy output

- **Raster based wind speed and wind frequency data**
- **Resolution 1000 x 1000m**

$$f(v) = \frac{k}{A}\left(\frac{v}{A}\right)^{k-1} * e^{-\left(\frac{v}{A}\right)^{k}}$$



Source: EUROWIND GmbH 2008

- **Calculation of annual energy output for every individual wind turbine**

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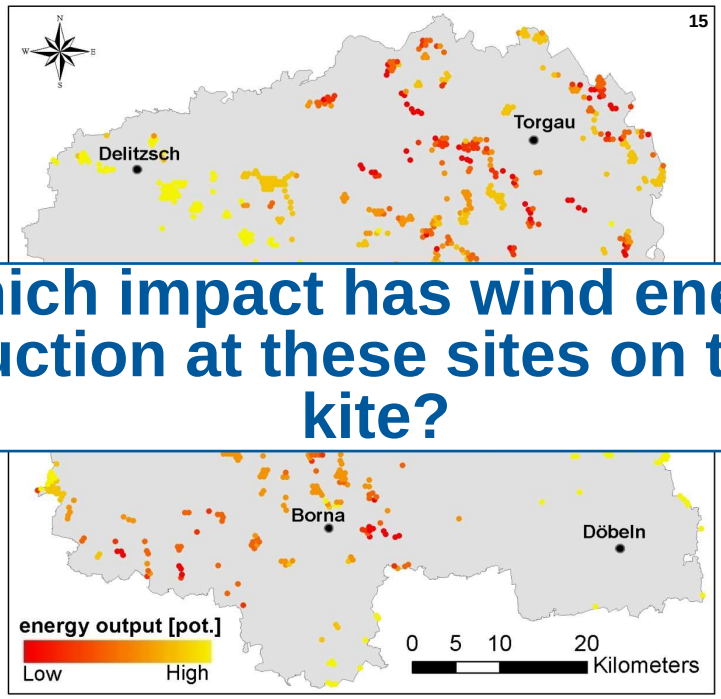
Modelling Framework – energetic criteria

Wind energy output



Where!

How many!

How much energy!

Which impact has wind energy production at these sites on the red kite?

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Modelling Framework – ecological criteria

Ecological impact of wind turbines on red kite

Assumptions:

- nearly all collisions occur during the breeding seasons
- 90% of all foraging flights during this time take place within a radius of 3km around aerie

Implication:

- **The more and the closer aeries are located to a wind turbine the higher is the collision risk!**

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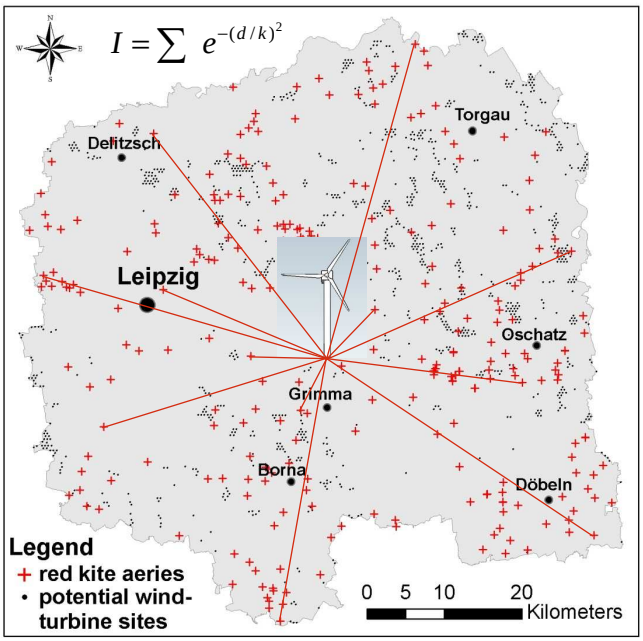
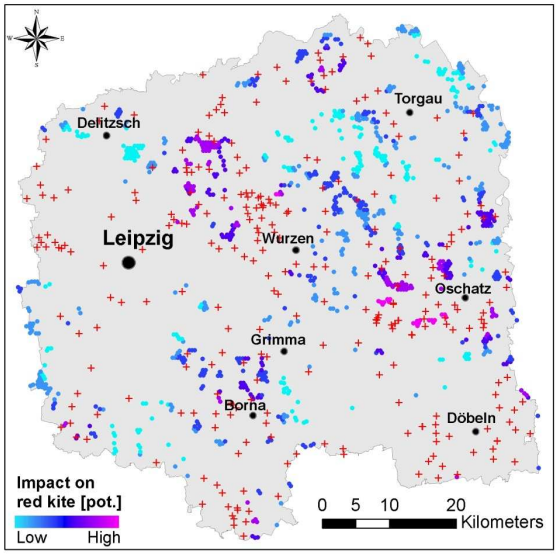
Modelling Framework – ecological criteria

Ecological impact of wind turbines on red kite





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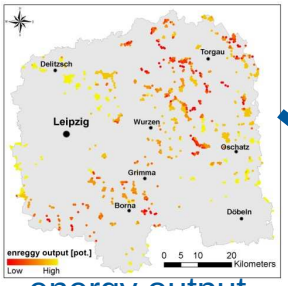
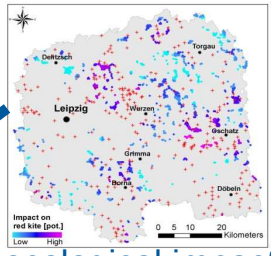
Modelling Framework – Wind Turbine Site Evaluation

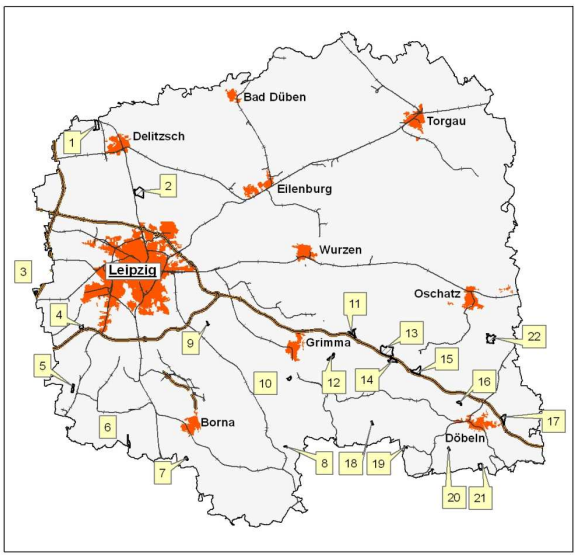


energy output
range 2 - 4 GWh

Ratio of energy output and ecological impact of the potential sites



ecological impact
range 0.04 - 10



more suitable sites
E. out = 3.4 GWh
E. imp = 0.2
Ratio = 17

less suitable sites
E. out = 2.3 GWh
E. imp = 9.1
Ratio = 0.2

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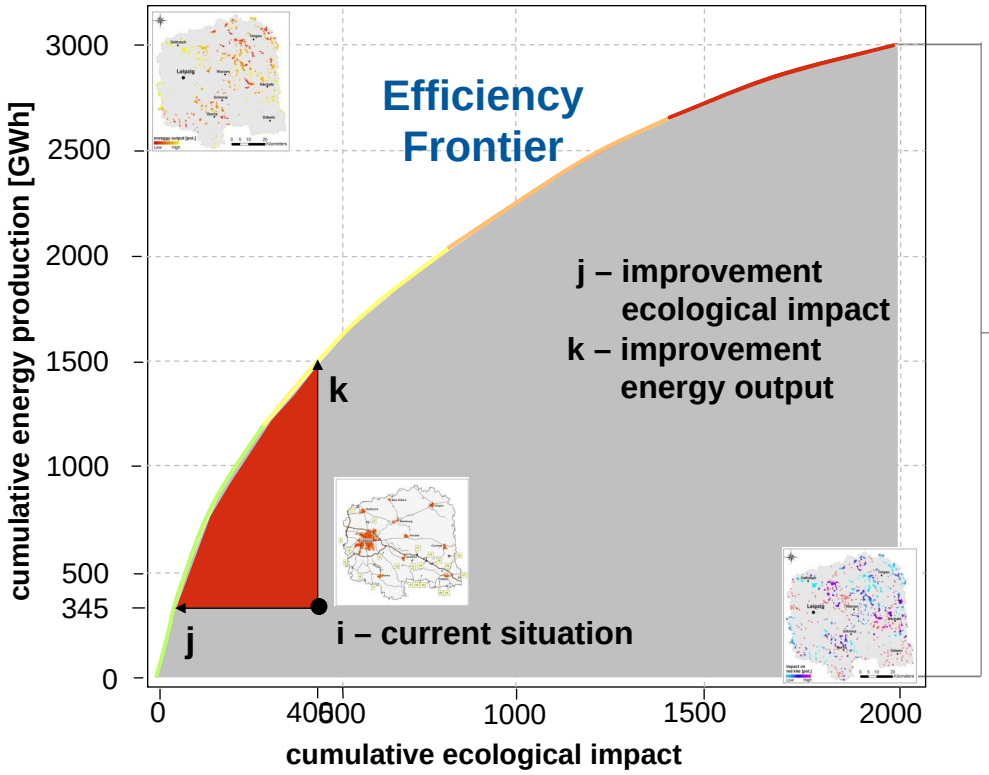
Results



Space of all possible but inefficient allocations

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Empirical Investigation of Societal Preferences

Characteristics of wind energy defined as **attributes** of environmental changes:

- **Height of the turbines**
- **Seize of a wind farm**
- **Impacts on local wildlife** (collision risk red kite)
- **Distance to settlement areas**
- **Cost** of allocation patterns (surcharge monthly power bill)

Survey presented to **German public** in summer 2008, including statements concerning **attitudes** toward wind power, etc. and **Choice Experiments**

Two representative studies (West Saxony; Northern Hesse)
nationwide online-survey

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Attributes and Levels of the Choice Cards

Attributes	Levels
Size of the wind farm	large (16 to 18 mills), medium (10 to 12 mills), small (4 to 6 mills)
Height of the wind mill	110 meter, 150 meter, 200 meter
Local nature impact	small, medium, large
Minimum distance to village/town	750 meter, 1.100 meter, 1.500 meter
Surcharge to power bill per month	€ 0 / € 1 / € 2,5 / € 4 / € 6

Note: underlined attribute levels describe programme A (constant least cost scenario)

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Example of a Choice Card

Program A represents status quo for wind power production in 2020

	Programme A	Programme B	Programme C
Size of the wind farm	**large farms**	**small farms**	**large farms**
Height of the wind mill	**200 Meter**	**110 Meter**	**110 Meter**
Local nature impact	**medium**	**low**	**medium**
Minimum distance to village/town	**750 Meter**	**1.100 Meter**	**1.500 Meter**
Surcharge to power bill per month	**€ 0**	**€ 6,-**	**€ 1,-**

40 Choice sets: blocked into 8 subgroups with 5 choice sets; each block presented to 44 respondents at least. **Completed interviews** in West Saxony: **353**.

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Results – Choice Experiments

Height of the turbines – not significant

Seize of a wind farm – not significant

Increasing the distance to settlement areas – positive WTP

Decreasing the impacts on local wildlife (collision risk red kite) – positive WTP

Welfare increases with increasing settlement distance and decreasing population loss.

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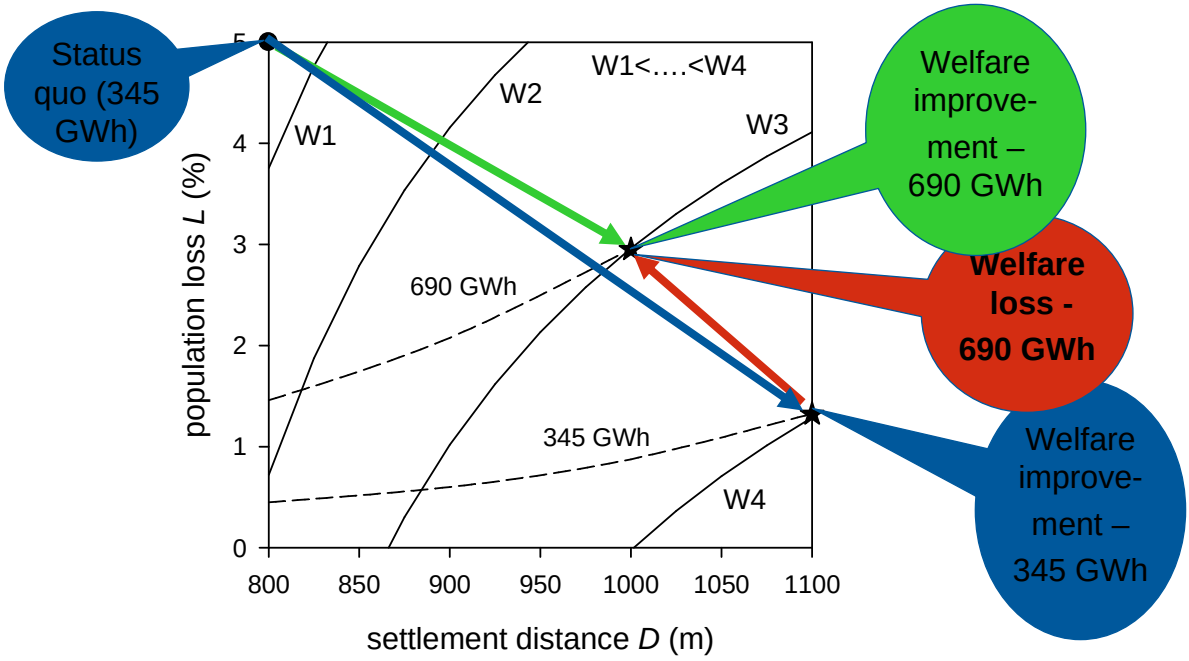
Results – Ecological-Economic Modelling



Solid lines: Iso-welfare curves (W)

Dashed lines: Efficiency frontier for two energy levels

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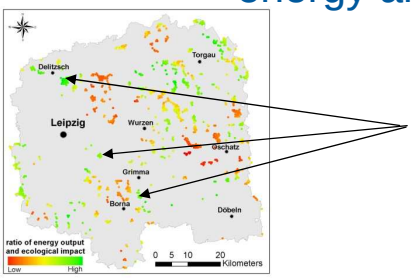
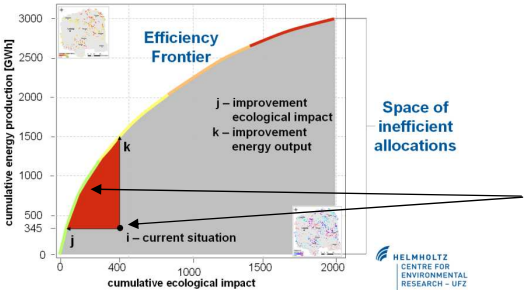
Discussion

Can we identify sufficient land area for wind power development in West Saxony in order to accomplish national energy and climate policy goals?



Yes we can!

Can we improve the current situation from a welfare economic point of view – even if the quota of regional wind energy supply is to double in future?



Yes we can!

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Thank you for attention!

Websites: http://www.ufz.de/index.php?de=14638

http://www.landschaftsoekonomie.tu-berlin.de/8359.html

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