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Analysis of Bioenergy Potential of Agriculture

1. *Estimation based on agricultural statistics*

2. ***Modelling of bioenergy***

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Method: biomass-yield-model

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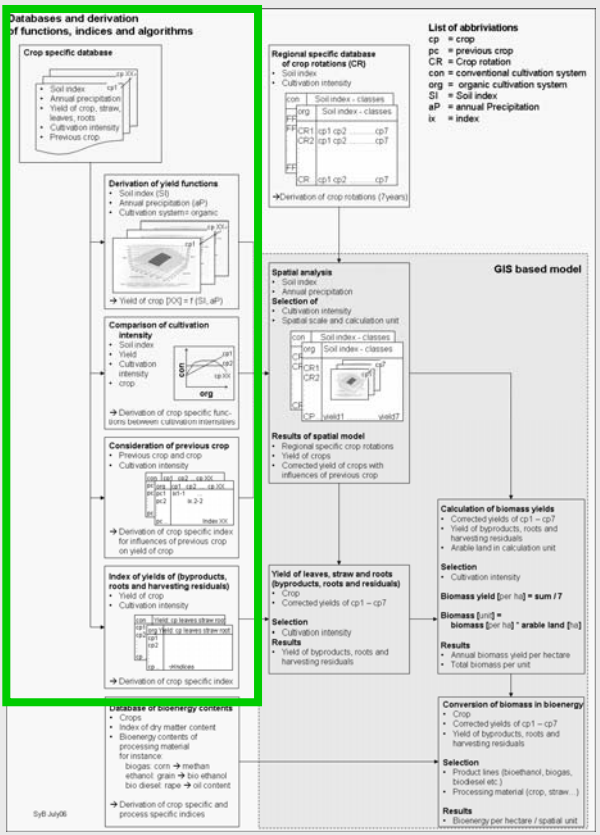

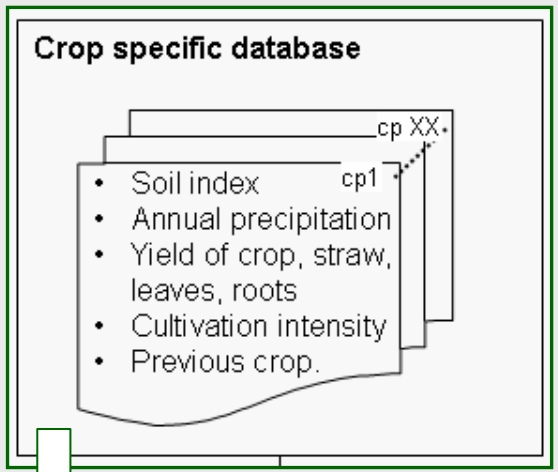

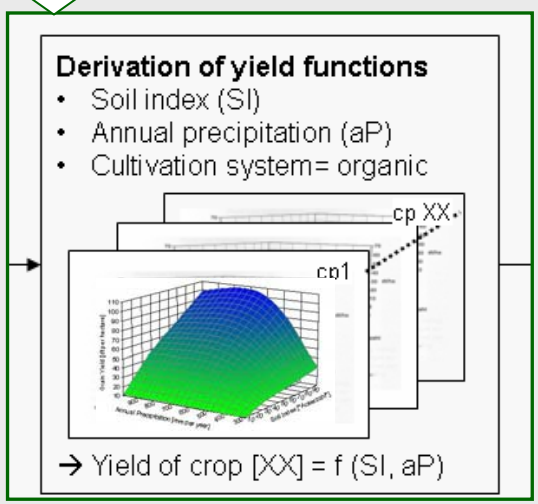

Working group
PIORR (1998)

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Method: biomass-yield-model

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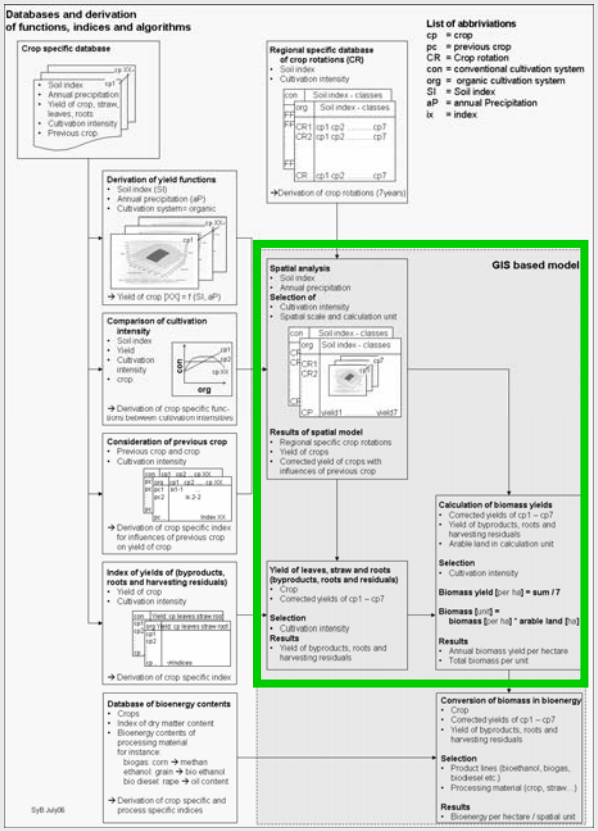

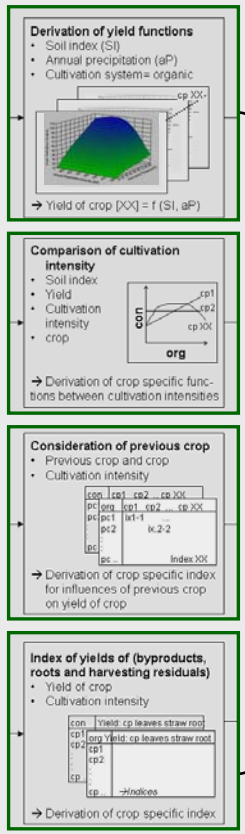

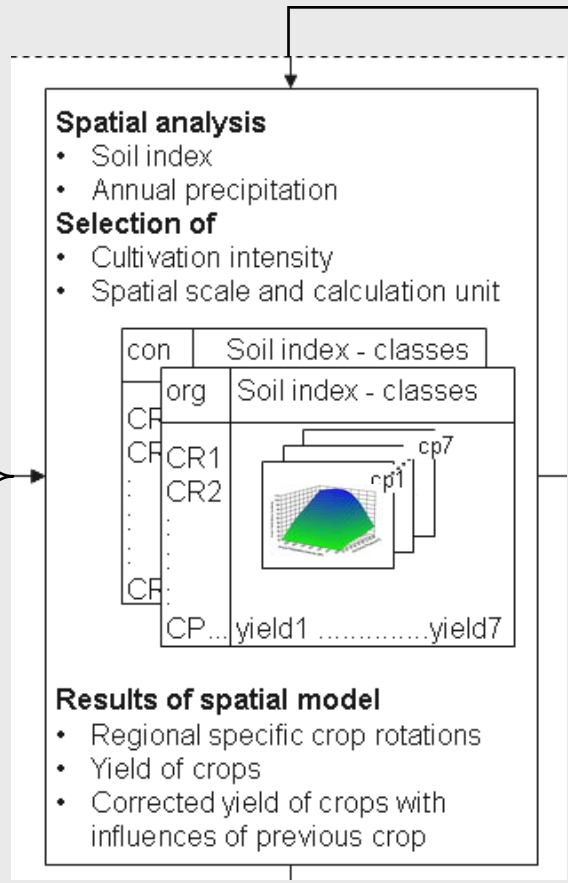

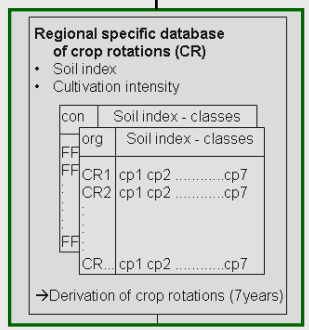

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Method: biomass-yield-model

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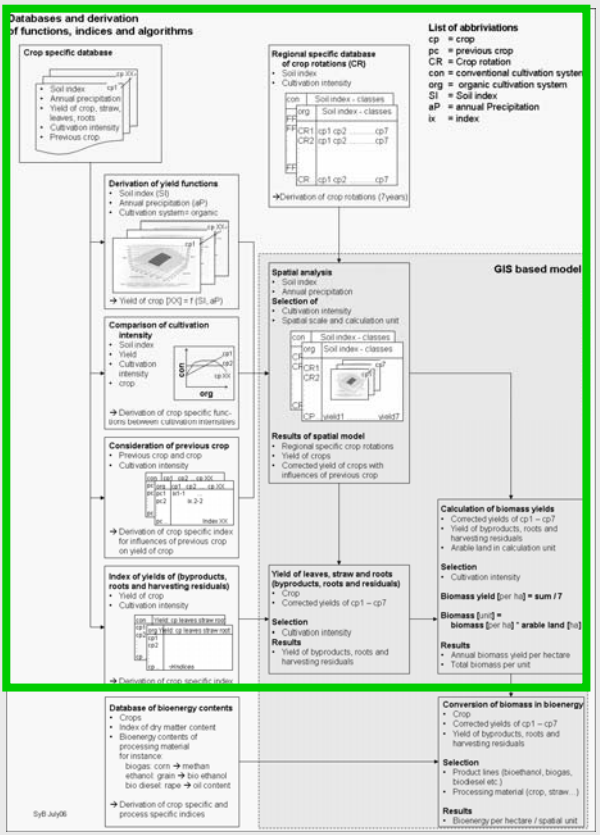

- Regional specific crop rotations (dominant crops for 7 years)
- Yield of crops with influences of previous crop
- Yields of by-products (straw and leaves), roots and harvesting residuals

---

Total biomass per hectare / spatial unit

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Method: estimation of bioenergy

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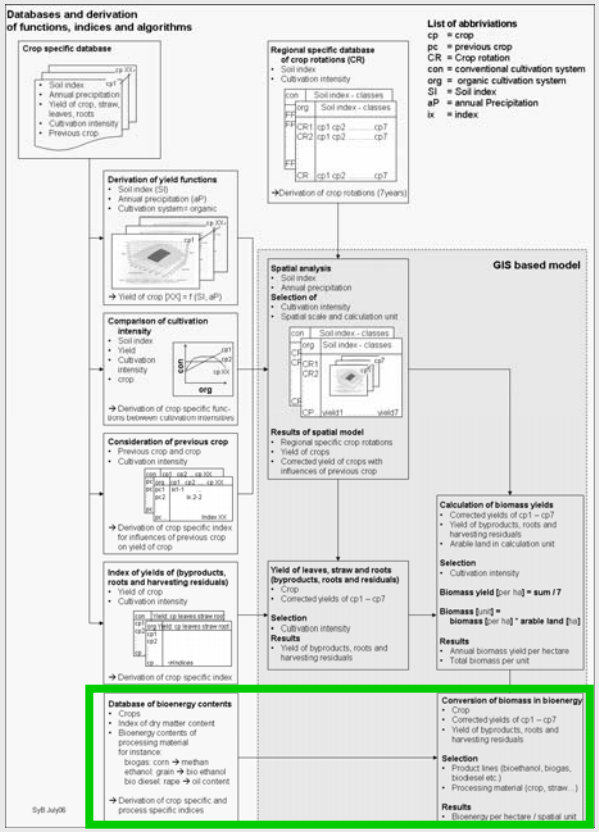

Database of bioenergy contents

- Crops
- Index of dry matter content
- Bioenergy contents of processing material
  for instance:
  biogas: corn → methan
  ethanol: grain → bio ethanol
  bio diesel: rape → oil content

→ Derivation of crop specific and process specific indices

Conversion of biomass in bioenergy

- Crop
- Corrected yields of cp1 – cp7
- Yield of byproducts, roots and harvesting residuals

Selection

- Product lines (bioethanol, biogas, biodiesel etc.)
- Processing material (crop, straw…)

Results

- Bioenergy per hectare / spatial unit

- ➢ Bioenergy per hectare / spatial unit
- ➢ Scenarios per product lines (**biogas**, bio ethanol, bio diesel)

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GIS programming

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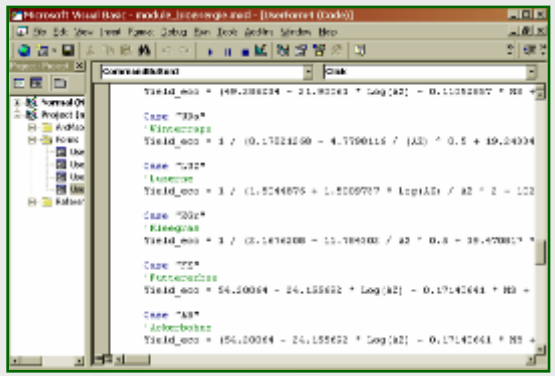
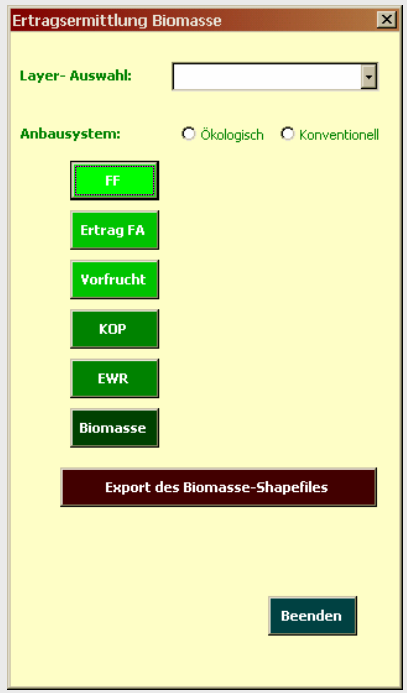


- ArcGIS 9 © ESRI
- Visual Basic for Application



Choose of

- Feature – Layer with input parameters soil index and precipitation
- Farming system: organic or conventional

- ➢ Assign of soil-specific crop rotations
- ➢ Calculation of yields and biomass

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Database: Germany

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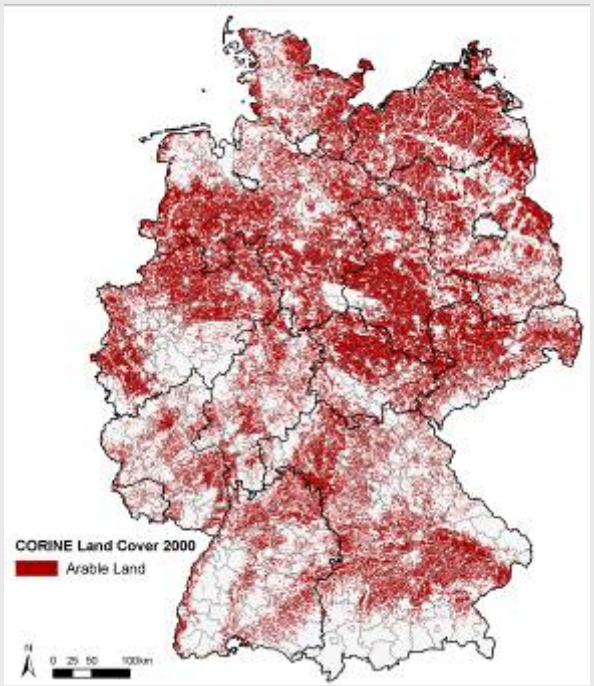
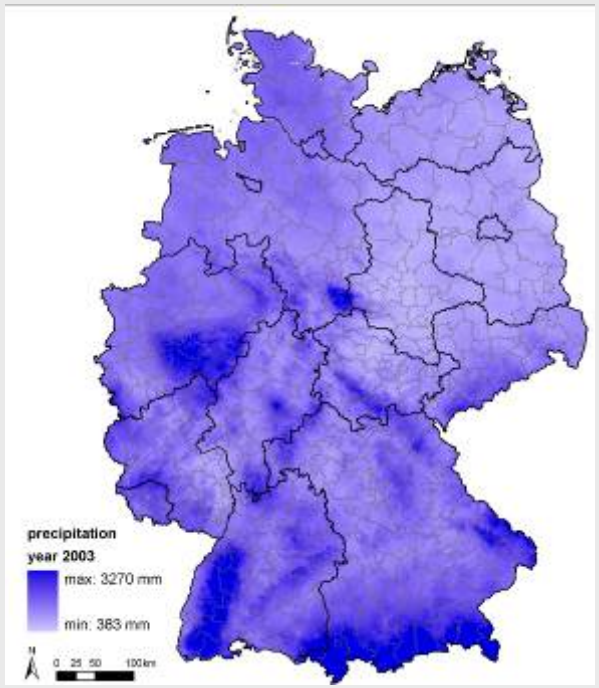
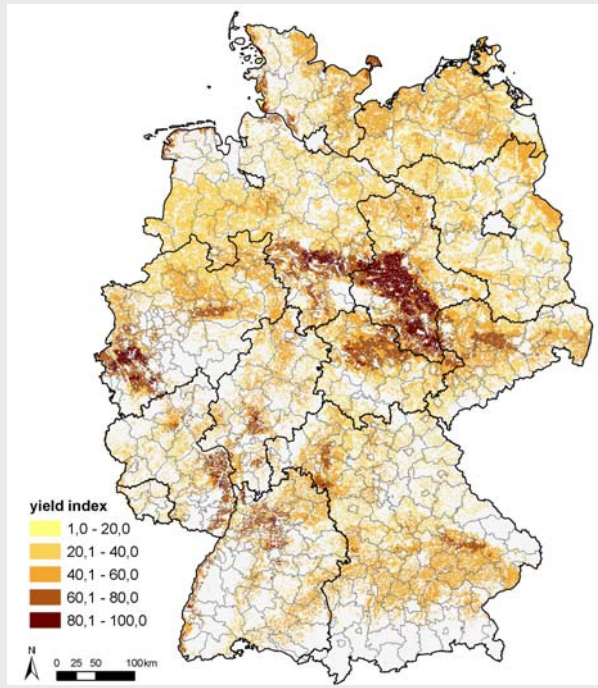
Land Use



Climate data



Soil index



Scale:	1:100.000	1:100.000	1:250.000
Cell size:	25 hectare	1 km²	National unit: municipalities
Input:	Arable land	Annual precipitation	German soil index “Ackerzahl”

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Database Europe: Land use

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Arable land

- CORINE Landcover 2000 (EEA)
- PELCOM – Datasets
  (Pan-European Land Use and Land Cover Monitoring)
- Remote sensing data – evaluation of land use changes
- National data sets with higher spatial exactness

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Database Europe: precipitation

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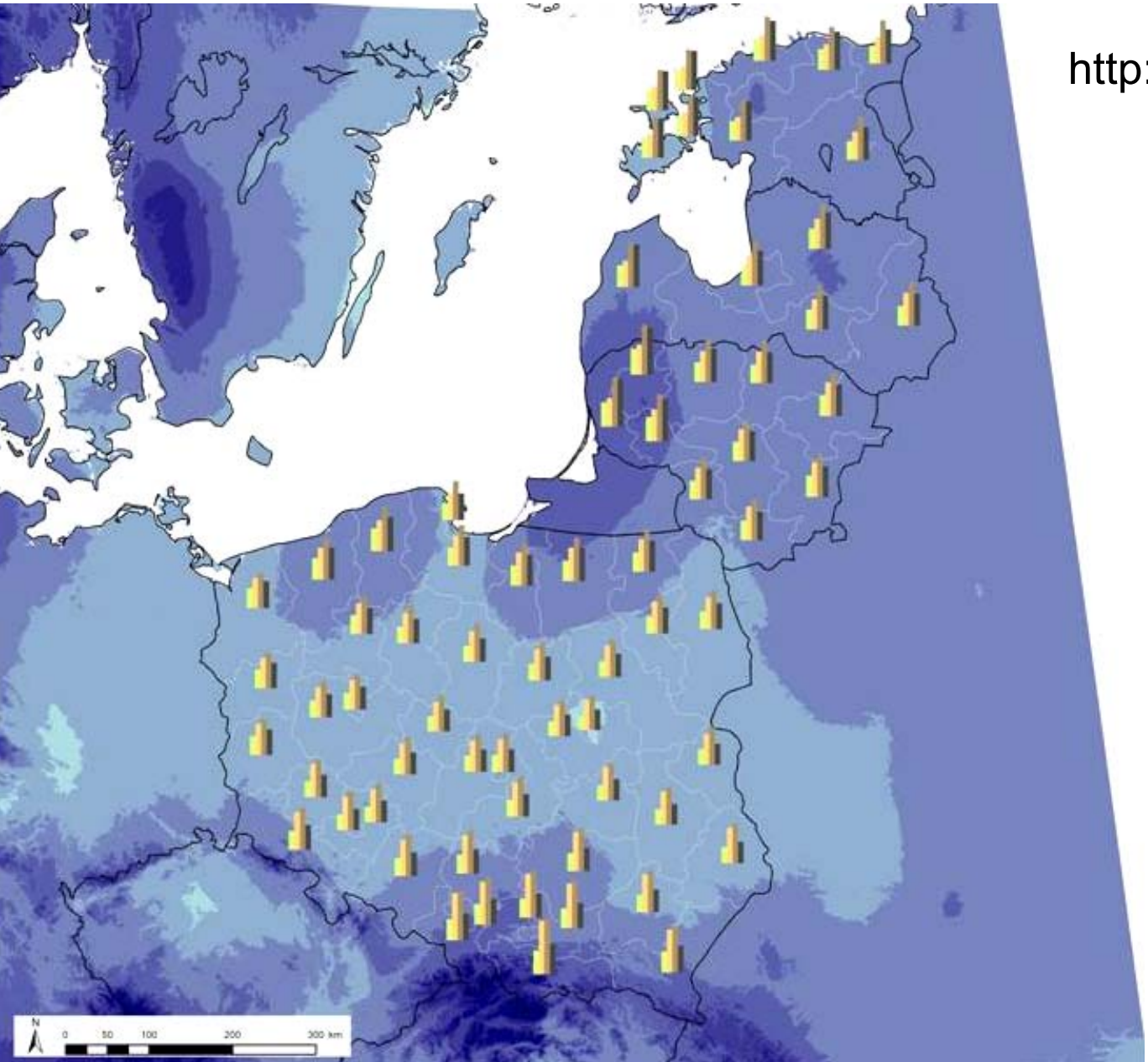

http://www.worldclim.org/

Annual Precipitation
(L * m^{-2})

Sum per quarter

Scale = 140mm

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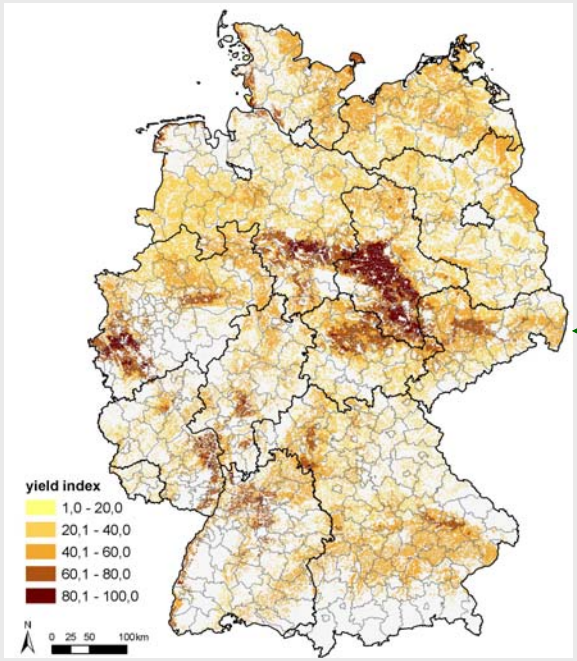
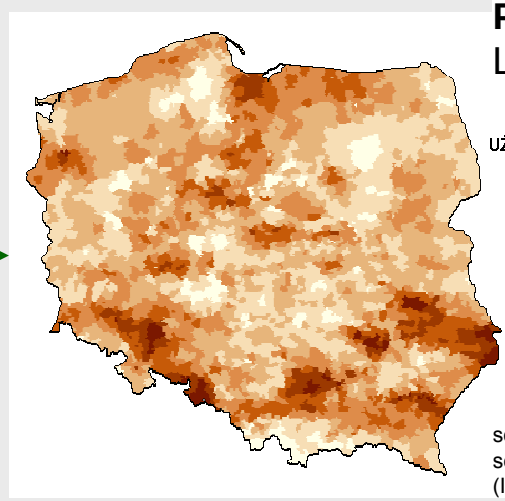
Database Europe: Soil data

Soil index



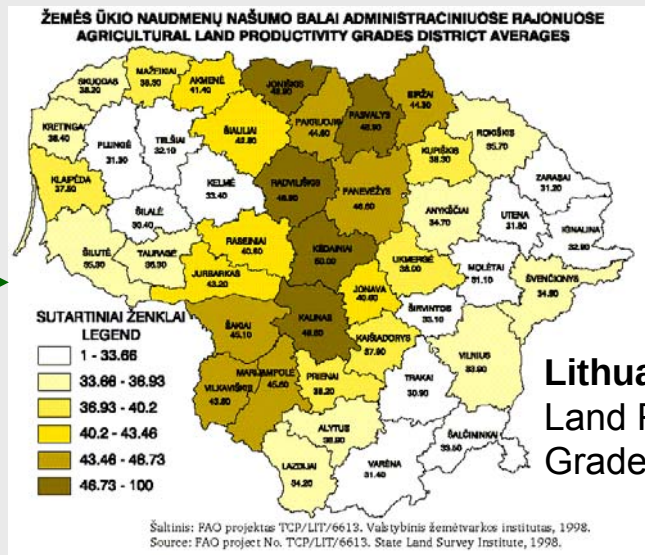
? = ?

Comparison of systematic necessary



Poland:
Land Quality Index

source: Institute of soil science and plant cultivation (IUNG), Poland



Lithuania:
Land Production Grades

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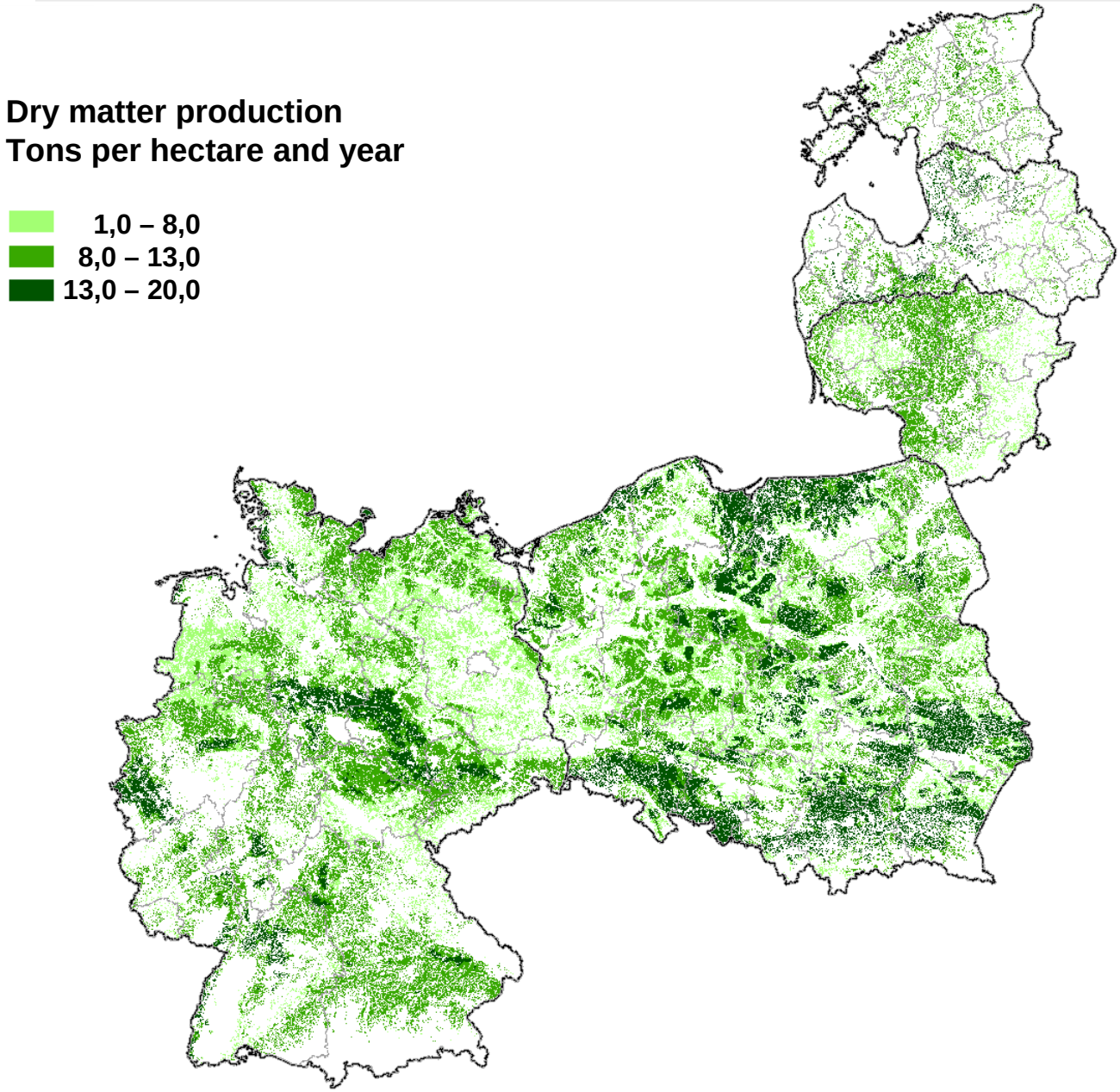
Result: annual dry matter production



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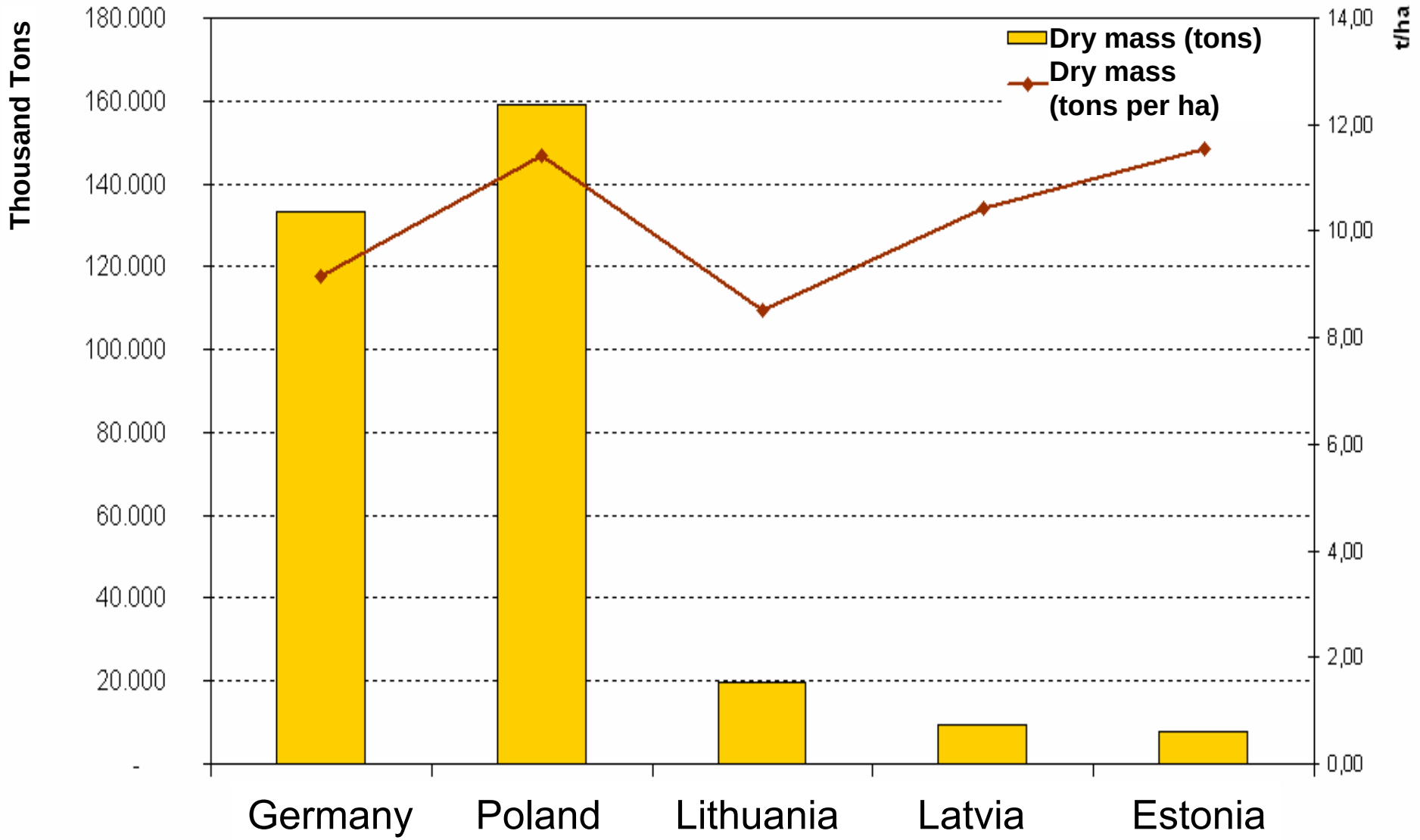
Result: annual dry matter production



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Potential analysis: biomass-yield-model

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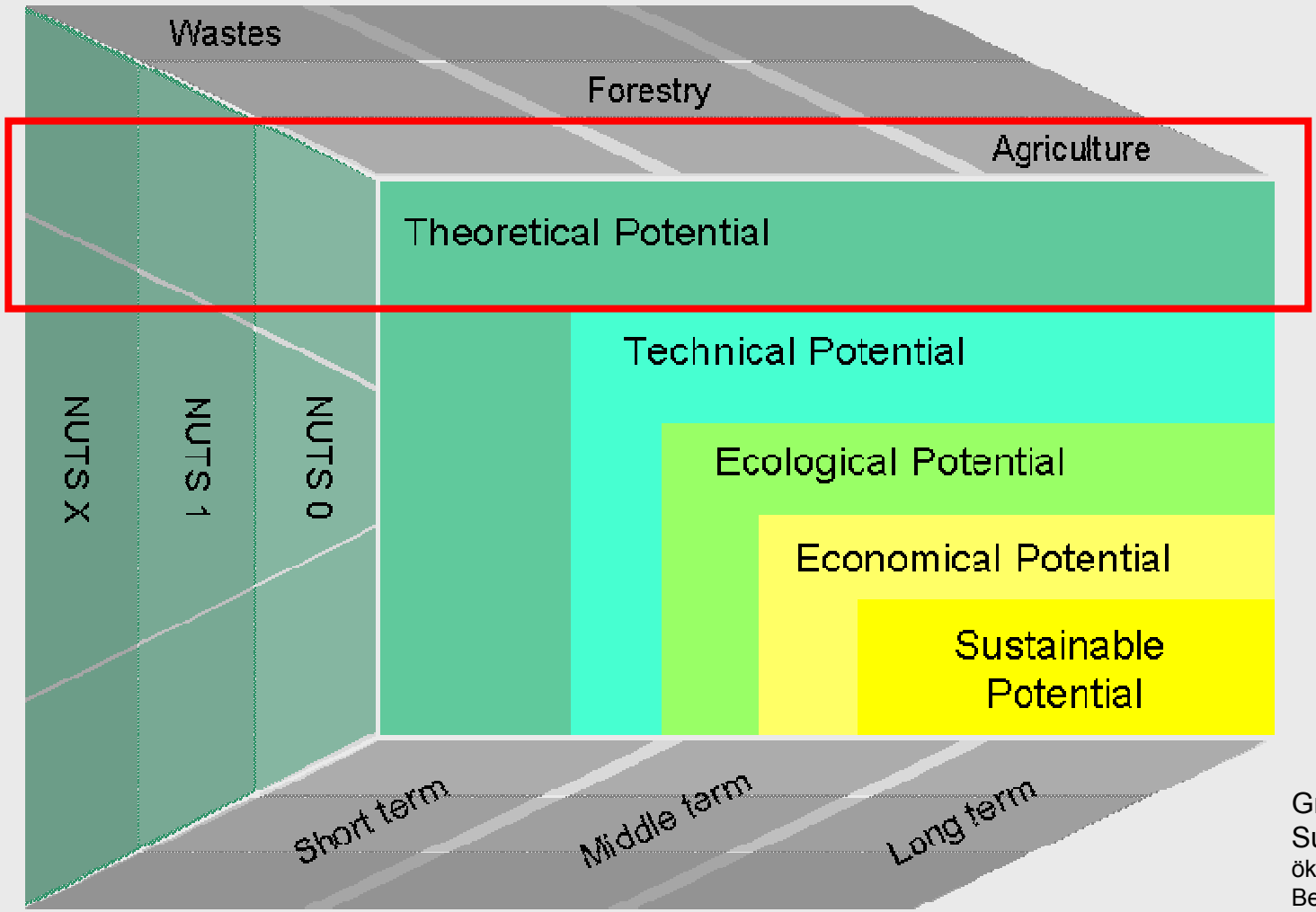

Source: Grundmann (2007)

Grundmann, P. (2007): SunReg – Modell zur ökonomischen und ökologischen Bewertung von Biomassepfaden in Betrieben und Regionen.

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Bioenergy potential of agriculture

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Evaluation of biomass production to bioenergy content according to **input materials** of several bioenergy product lines

- Biogas: whole plant - silages
- Bio ethanol: grain
- Bio diesel: rapeseed
- Synthetically bio fuels: dry mass (e.g. straw)

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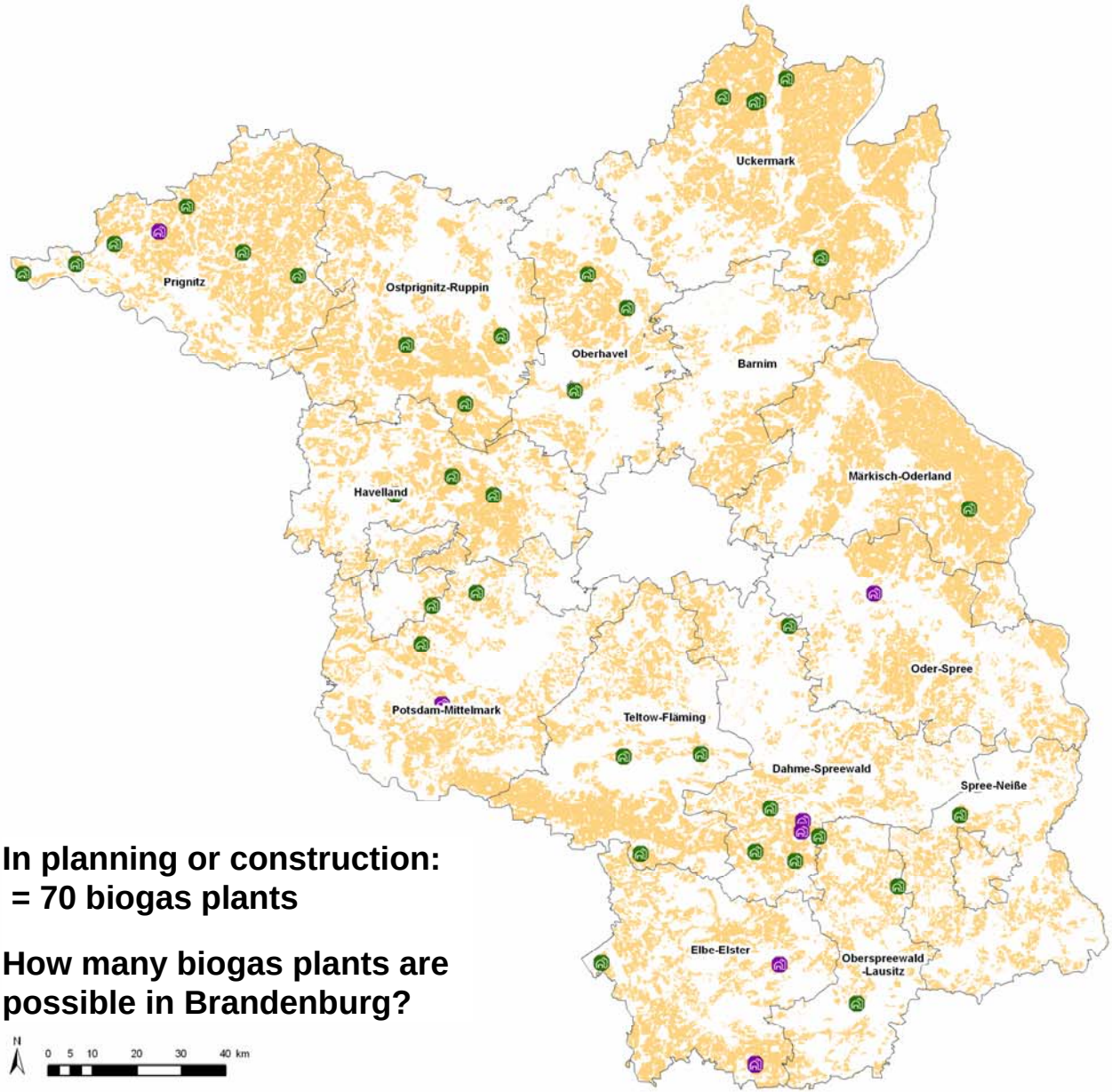
Bioenergy potential: biogas



Situation of biogas production in Brandenburg

(October 2006)

- Agricultural plant
- Waste plant
- Arable land
- Counties of Brandenburg

In planning or construction:
= 70 biogas plants

How many biogas plants are possible in Brandenburg?

N 0 5 10 20 30 40 km

Bearbeiter: Dipl.-Geoökol. S.Brozio;
Dipl.Ing (FH) D.Müller; Fachhochschule Eberswalde
Arbeitsstand: 20.10.2006

Zielvereinbarung "Potenzialstudie Bioenergie" zwischen FH Eberswalde und Ministerium für Wissenschaft, Forschung und Kultur Brandenburg

Baltic Biomass Network

Projekt teilfinanziert durch die Europäische Union

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Biogas: available raw material

Corn: Potential yield of corn (whole plant)

- minus spatial differenced percentage of corn for **animal feeding**

Winter rye: Potential yield of corn and straw: amount of whole plant

- minus 35% for **food production**
- minus spatial differenced percentage of straw for
  - **humus reproduction**
  - **animal bedding**

→ Sum of available material

= *Silage material for Biogas production*

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Biogas: humus reproduction

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… spatial differenced percentage of straw

- Harvesting amount per year
- Calculation of humus reproduction of non-used by-products (leaves of potatoes, straw of rape)
- Statistics of Livestock farming → conversion to amount of manure
- Regional differenced distribution of manure

- ➢ Positive humus balance (+ 100 kg C/ha)
- ➢ Available straw = part of straw not used for reproduction of positive humus balance

Biogas: humus balance

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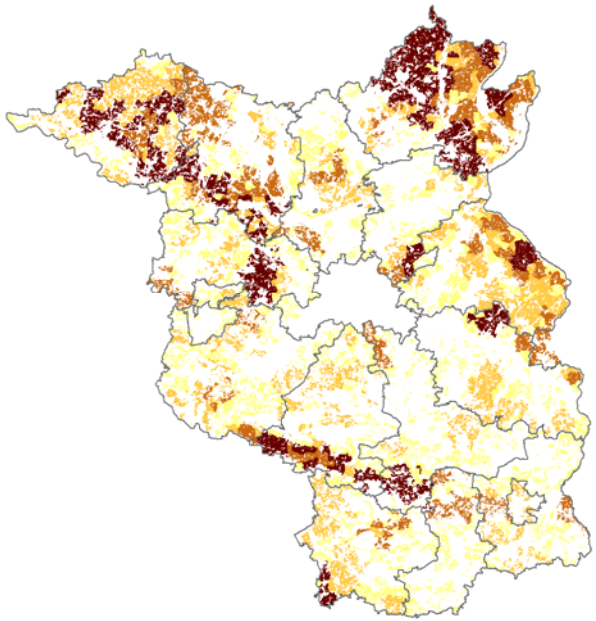
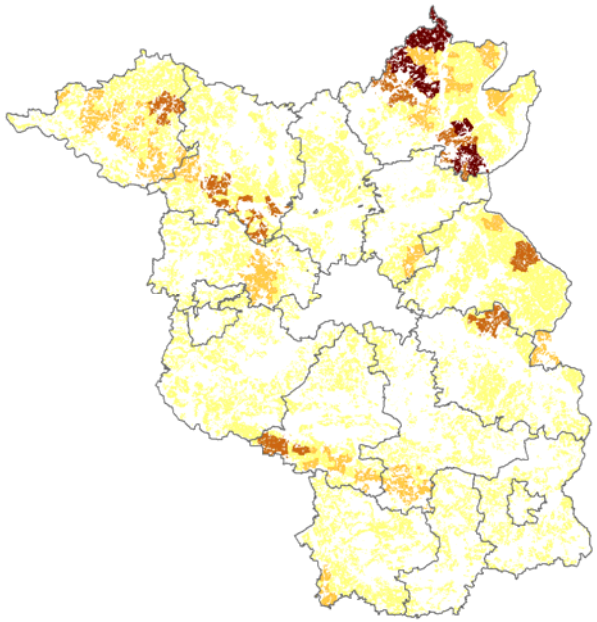
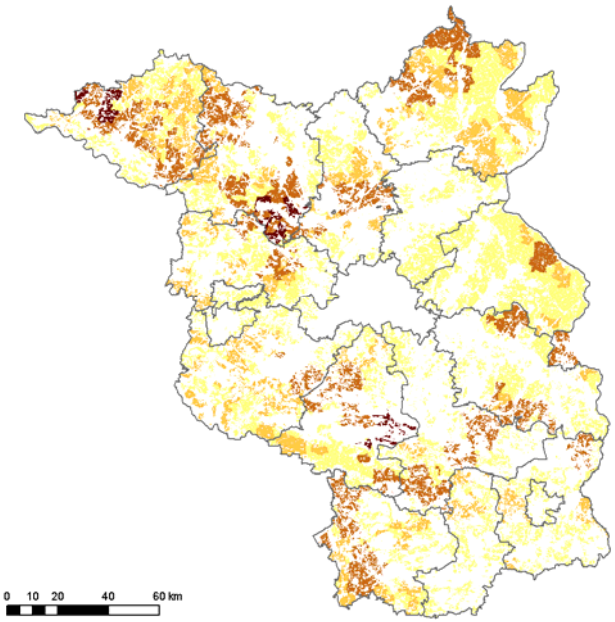
Extract of humus by crop harvesting



Reproduction harvesting residuals



Reproduction manure



low high

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Biogas: available straw

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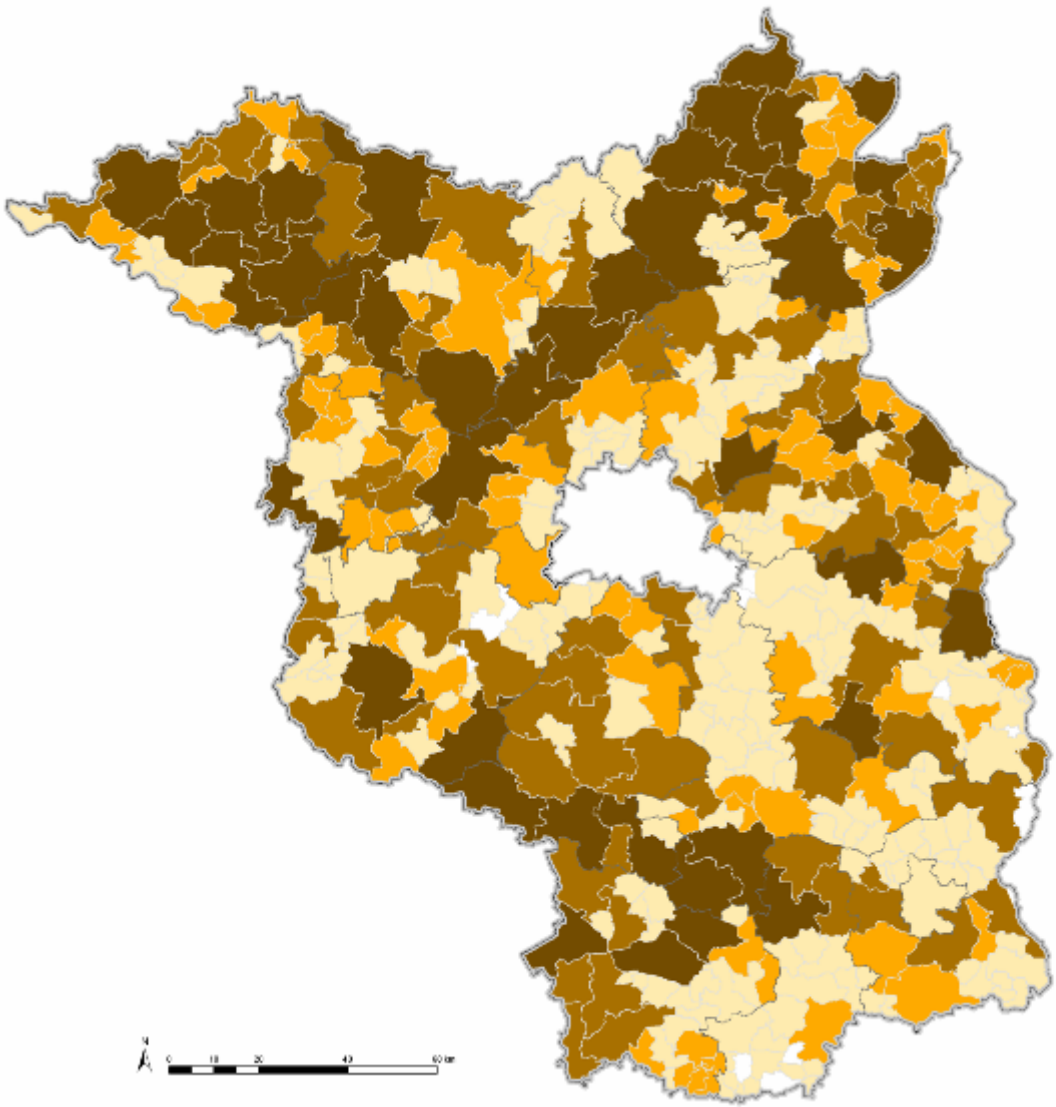

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Biogas: biogas content

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1) **Silage** of

   - 10 % losing material during process of silage production

   Winter rye: 325 kWh_{el} / tons
   Corn: 335 kWh_{el} / tons

2) Statistics of Livestock farming:
   stock of cattle → conversion to amount of liquid manure:

   manure slurry of cows: 42 kWh_{el} / tons
   manure slurry of pigs: 37 kWh_{el} / tons

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Biogas potential: electrical power

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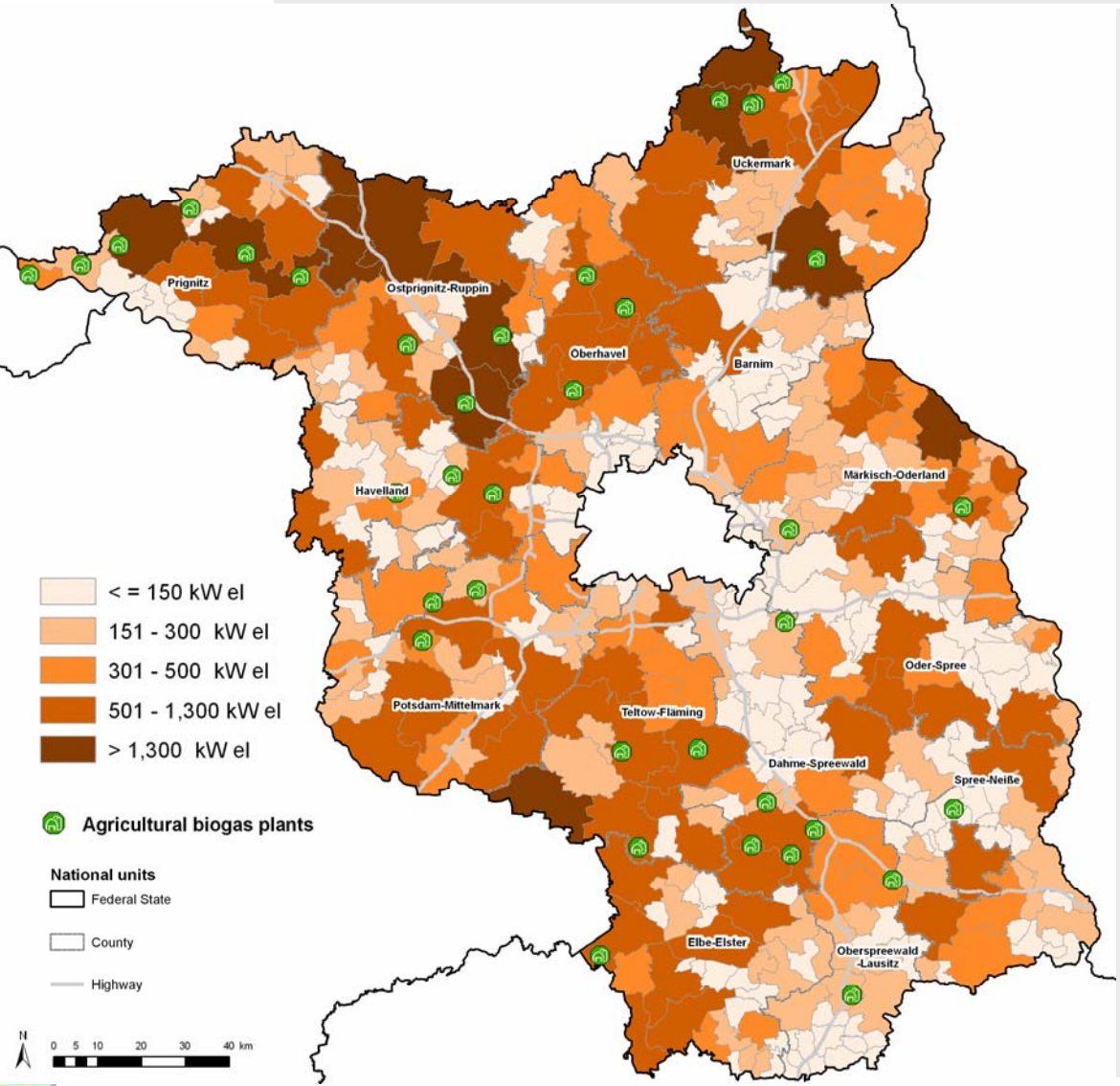

Brandenburg

- Efficiency: 32%
- Working hours: 7,500 per year
- Scaling of the map: size of power plants

Based on:

- Silage of corn and winter rye
- Liquid manure

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Biogas potential: amount of plants

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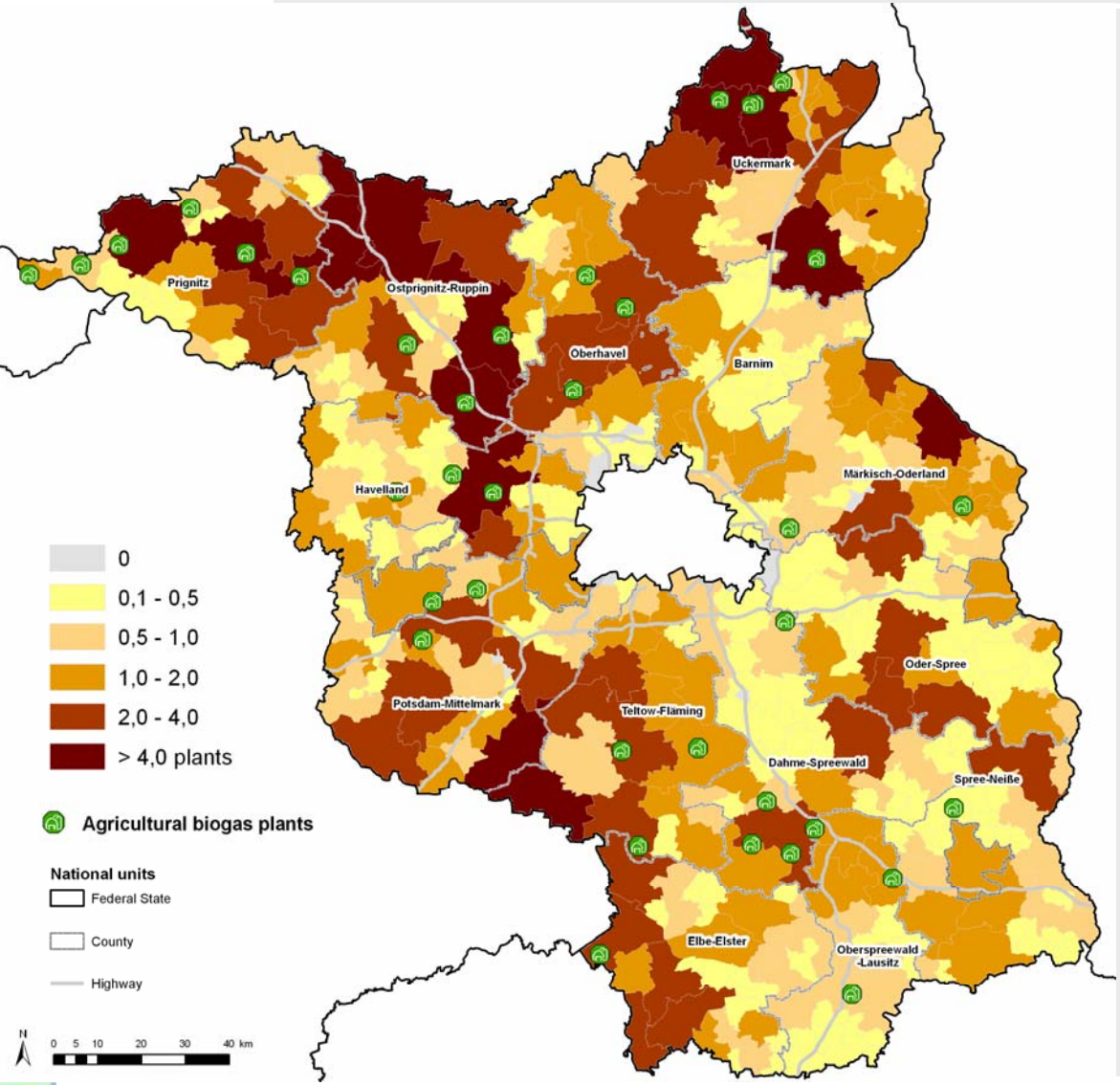

Brandenburg

- Efficiency: 32%
- Working hours: 7,500 per year
- **Standardizes on biogas plants with 300 kW_{el}**

Based on:

- Silage of corn and winter rye
- Liquid manure

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Biogas potential: amount of plants

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National unit	Arable land	Potential yield of elect. Power in 1000 MWh / a	Biogas plants 300 kW_{el}	Biogas plants 500 kW_{el}
Barnim	42.213 ha	29,5	13	8
Uckermark	150.760 ha	139,4	62	37
Brandenburg	12,3 Mio. ha	918,2	**408**	**244**

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Biogas potential: Brandenburg

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918,2 MWh electrical power means:

≈ theoretically **23.7%** of all private households in Brandenburg could be supplied with electricity from biogas.

≈ 3,3 PJ + **7,8 PJ heat**

Or biogas in equivalent of

≈ 275 mill. m³ natural gas

≈ 148,980 t gasoline

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Potential analysis

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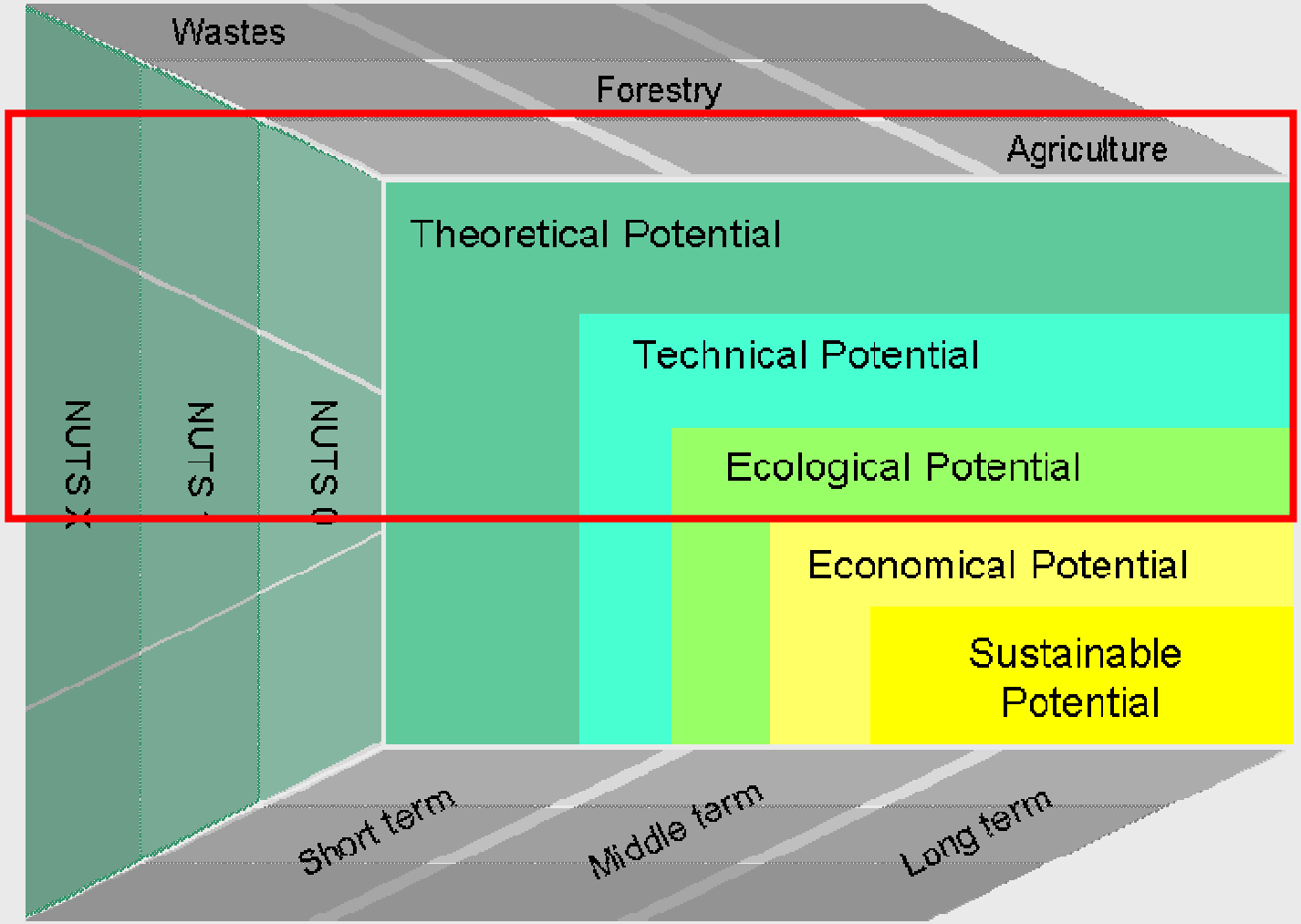

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- √ Biogas
- Bio ethanol
- Bio diesel
- Synthetically bio fuels

  - Central bioenergy plants
  - Visualisation of supply areas
  - Scenarios

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Supply area:

- Regional potential amount of annual yield of input material (grain, sugar beet, rapeseed)
- Consumption of bioenergy plant and compare to regional yields

  e.g. Bioethanol – Plant Schwedt (North East Germany)

  - capacity of 180,000 t bio ethanol = 600,000 t grain of winter rye per year
  - next years: grain of rye, triticale, barley, wheat

Scenarios:

- Availability of grain: concurrences to food and fodder
- Supply areas of dry year
- Modelling of energy crops and energy crop rotations

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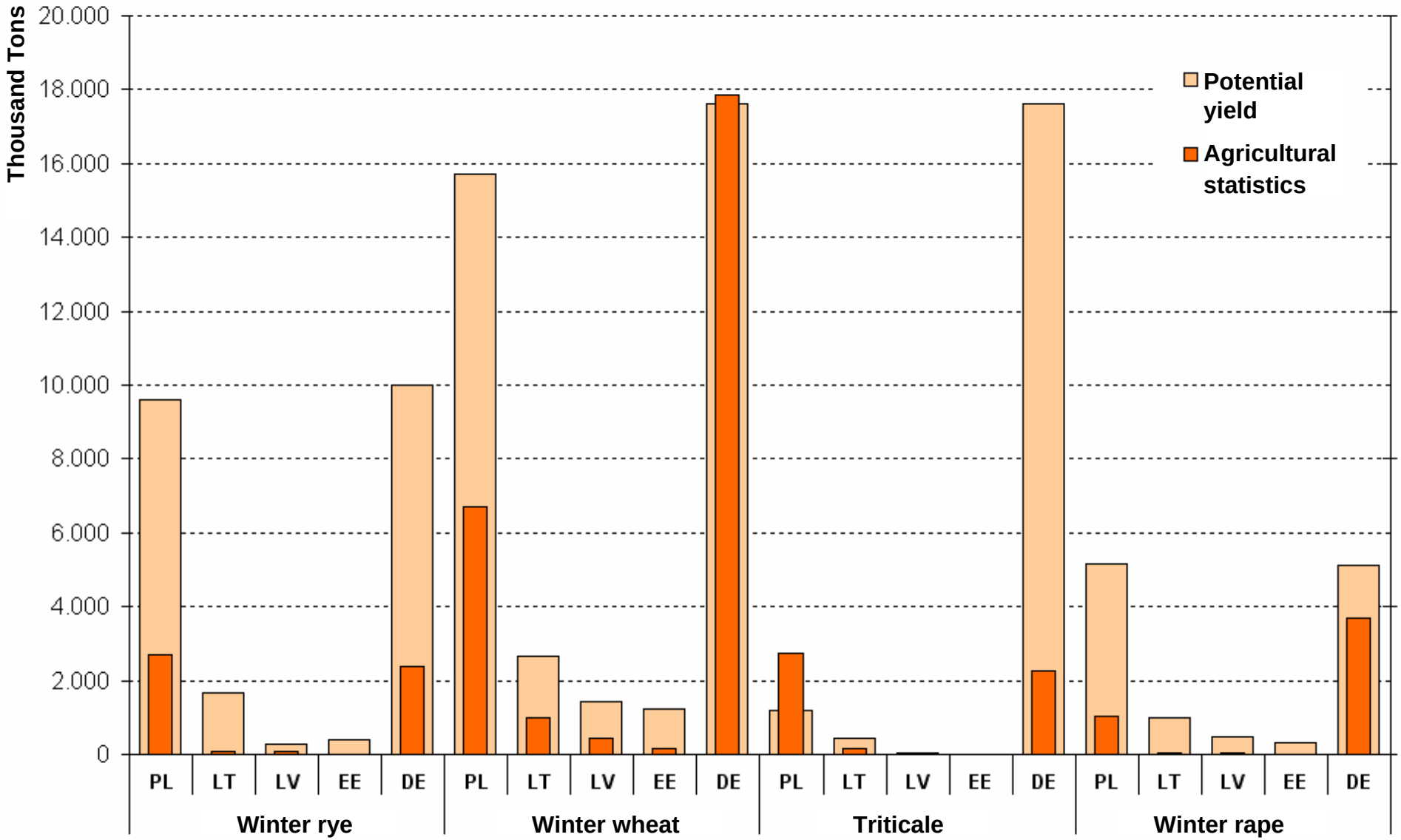
Result: crops rye, wheat, triticale, rape



Result: Bio ethanol, Bio diesel

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Potential of federal state Brandenburg (BB)

	Grain (100%) Rye, Triticale, Wheat, Barley	**Winter rye** (35 % for food and fodder)	**Winter rape** (100 %)
Yield amount in Tons	2.256.874 t	605.900 t	251.160 t
Bio ethanol in Litre	939.615.190 l	246.743.480 l	
Bio diesel in Litre			98.798.680 l
	Demand of gasoline 1074 Mio. Litre		**Demand of diesel** 1073 Mill. Litre
Comparison to demand in BB 2003	**56,8 %**	**14,9%**	**8,4 %**

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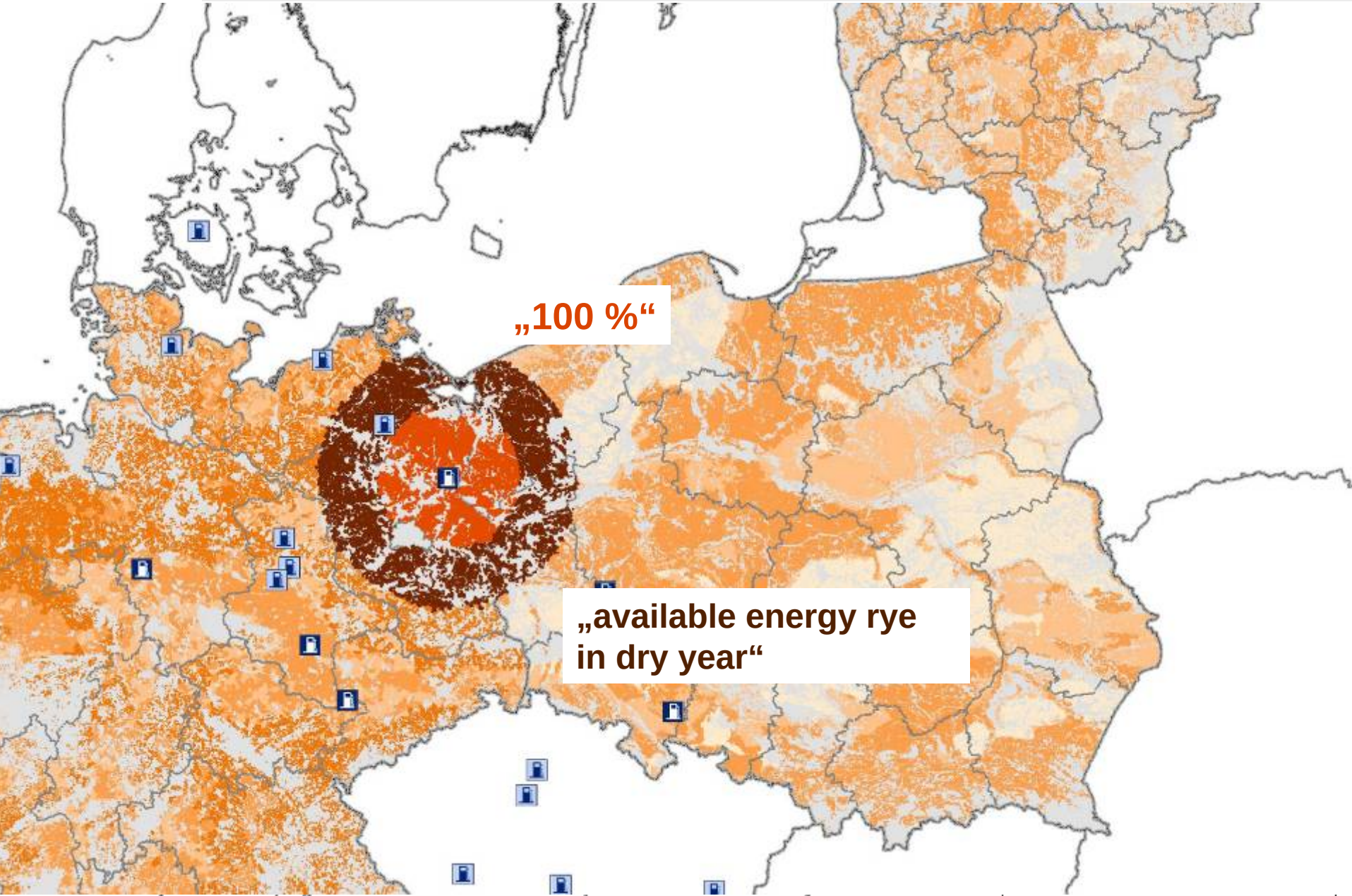
Scenario: Bio ethanol

Winter rye



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Potential analysis

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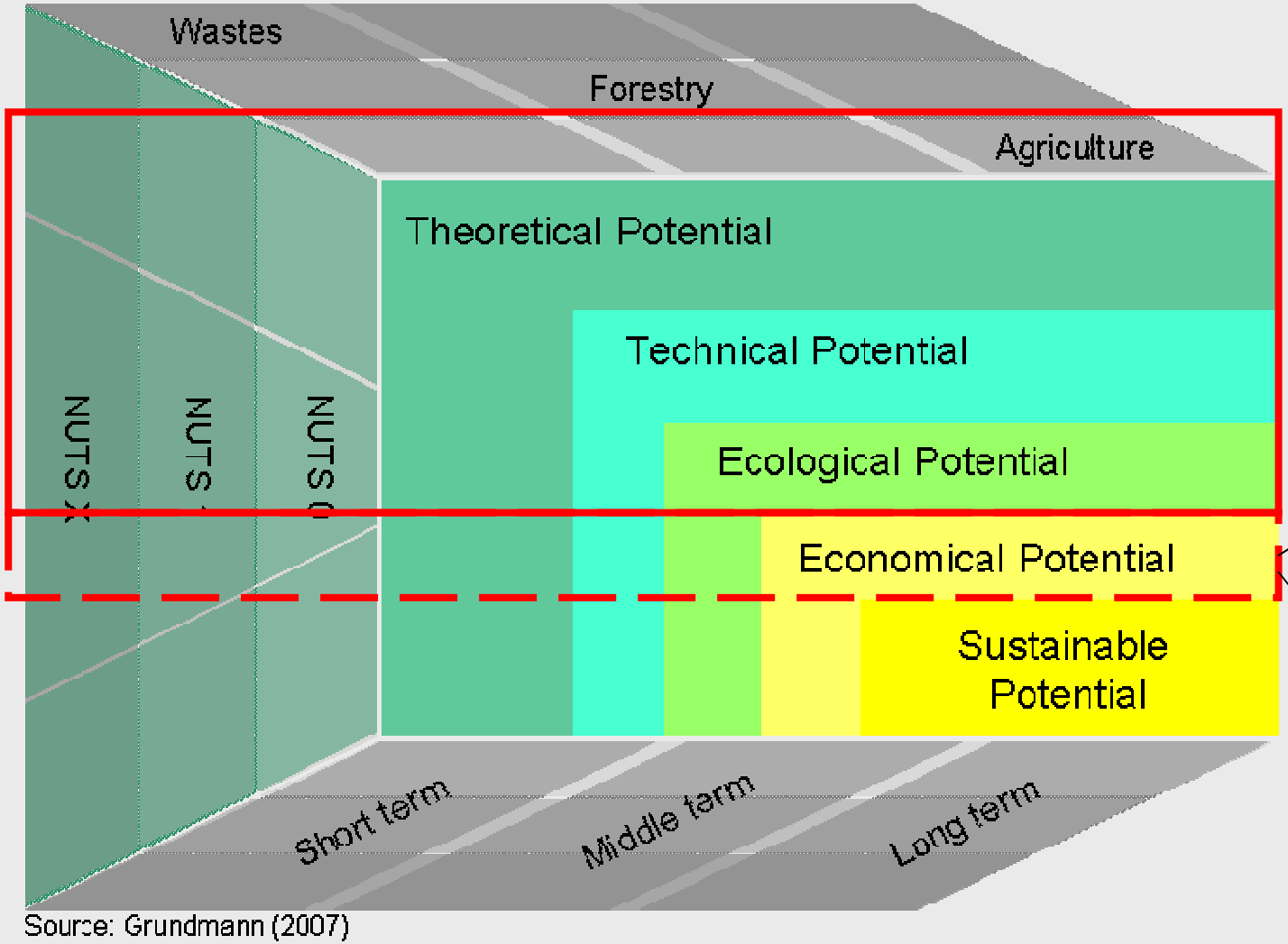

Source: Grundmann (2007)

- **Economic Scenario**
- Logistic

Grundmann, P. (2007): SunReg – Modell zur ökonomischen und ökologischen Bewertung von Biomassepfaden in Betrieben und Regionen.

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Potential analysis: Economic scenarios

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Heiko Zeller:

Economic scenario of energy crops

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Scenario: economic

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Result of economic scenario: change of cultivation areas of crops

→ Change of crop rotations

Soil class	Crop rotation in „biomass-yield-model“	Crop rotation according to economic scenario 1
LBG IV	barley - potato - rye - corn - barley - rye - *oats*	rye - corn - barley - rye – potato - **wheat** - barley
LBG III	rape - wheat - rye - triticale - *barley* - rye - barley	rape - rye - **corn** - wheat - rye - triticale - barley
LBG II	rape - wheat - *barley* - rye - corn - wheat - barley	rape - wheat - corn - rye - **rape** - wheat - barley
LBG I	rape - wheat - *barley* - su.beet - corn - wheat - barley	rape - wheat - su.beet - **wheat** - rape - corn - wheat

LBG = „Landbaugebiet“: area of equal yield levels

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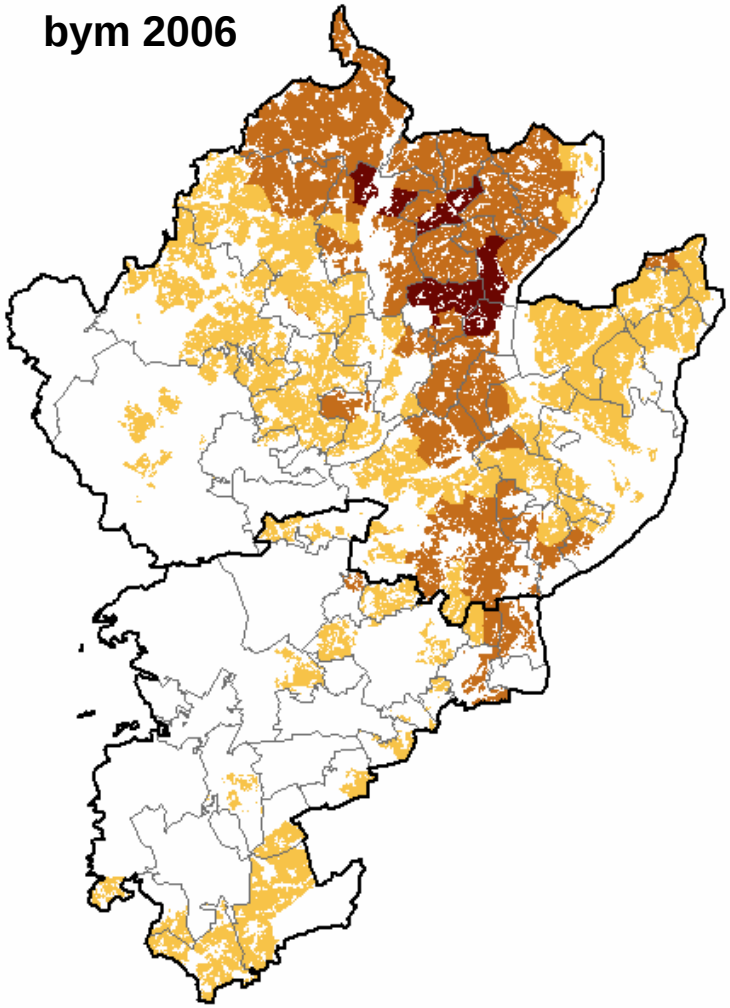
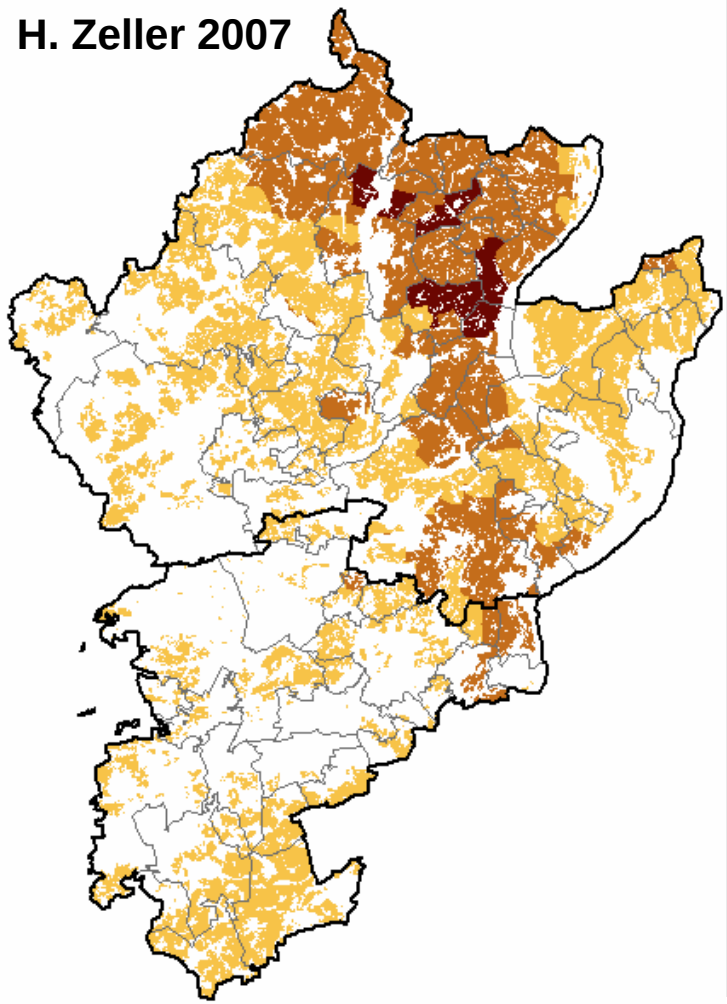
Change of cultivation area

bym 2006



H. Zeller 2007



Potential yield level

low high

National units

County

Community

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Scenario: economic

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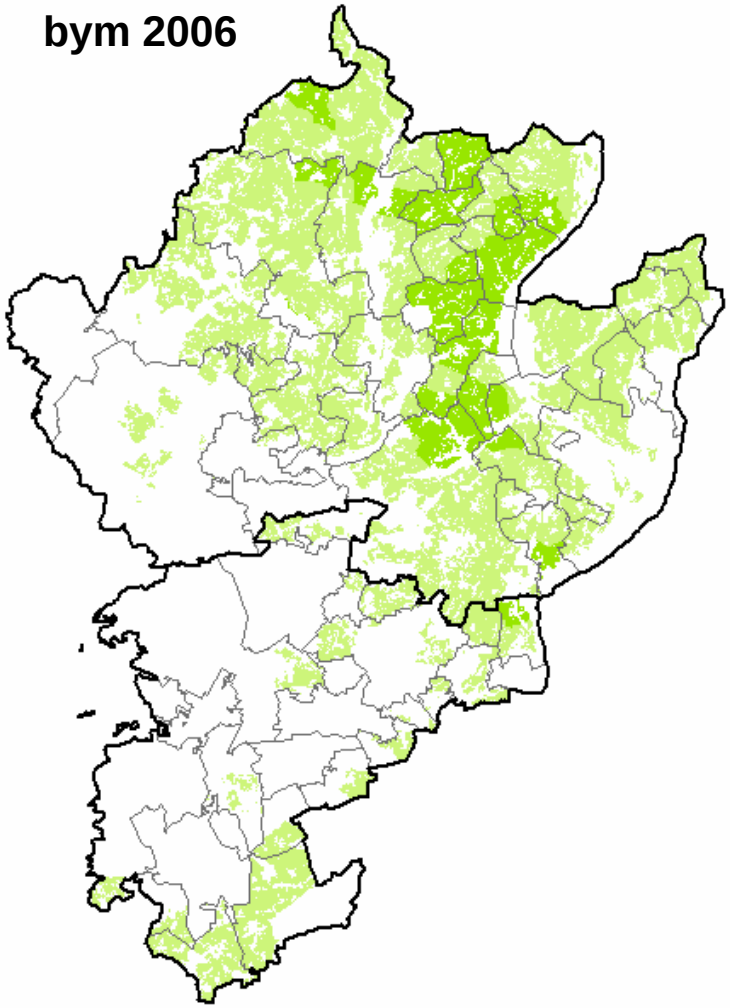
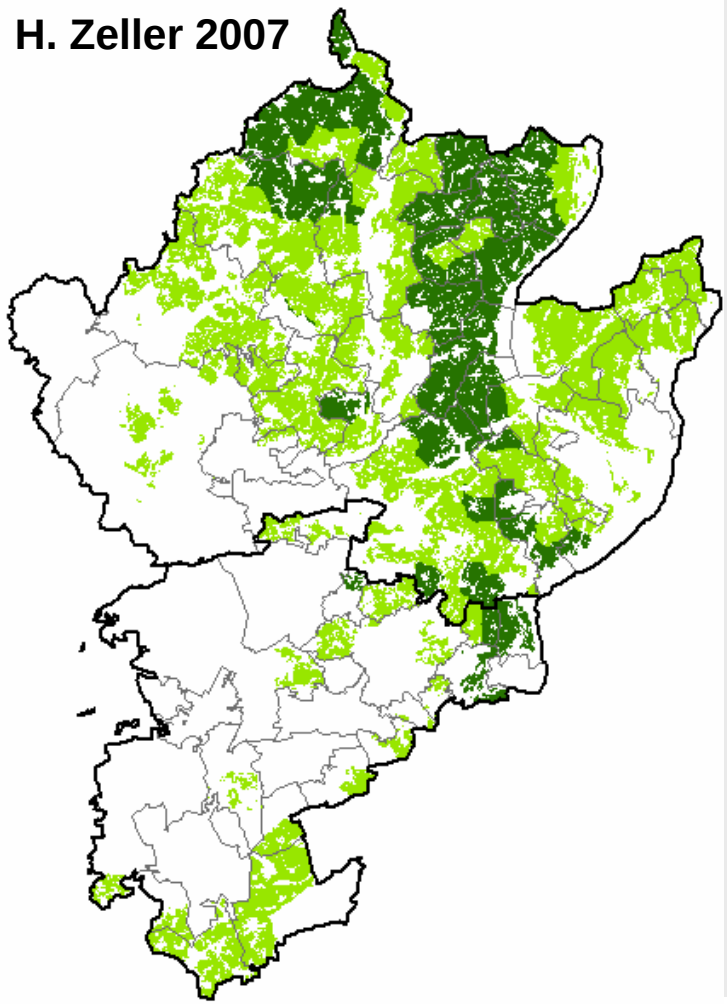
Change of cultivation frequency

bym 2006



H. Zeller 2007



Potential yield level

low high

National units

County

Community

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