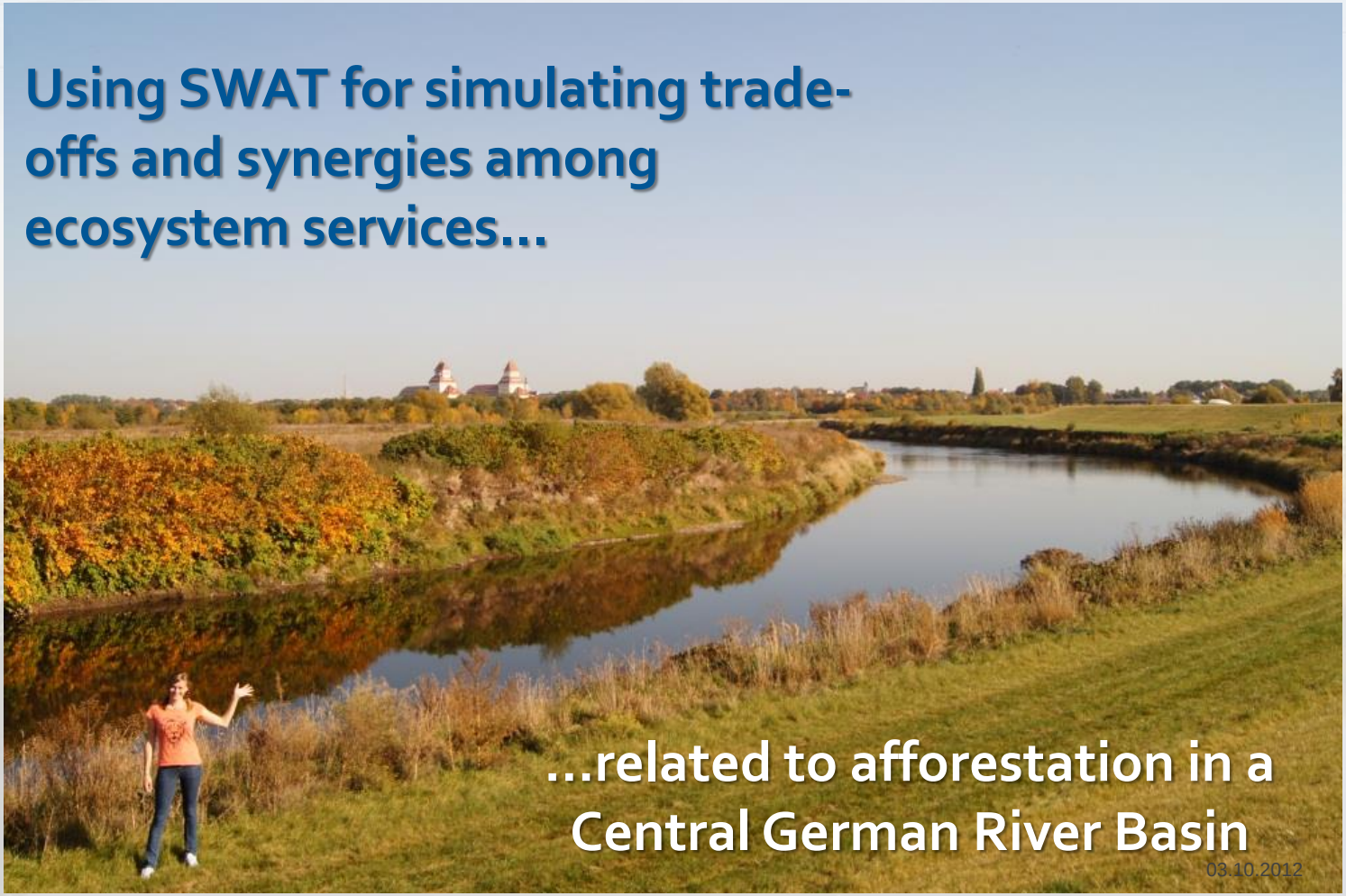
Using SWAT for simulating trade-offs and synergies among ecosystem services…



…related to afforestation in a Central German River Basin

03.10.2012

Susanne Mühlner,

Felix Witing, Sven Lautenbach & Martin Volk

SWAT Conference Toulouse, 17.-19.07.2013
Session B1: Environmental Applications

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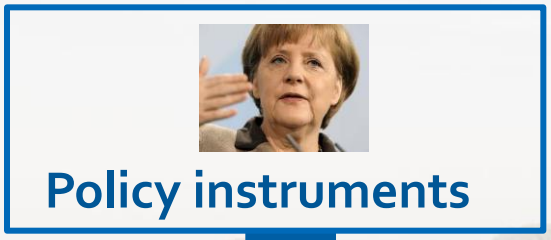
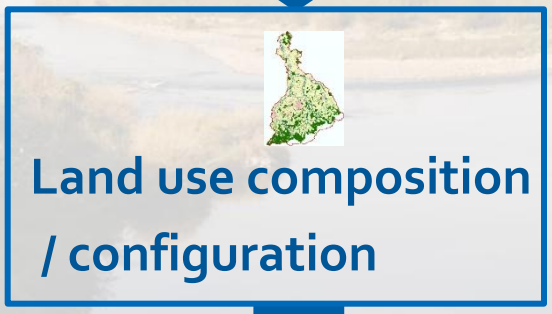
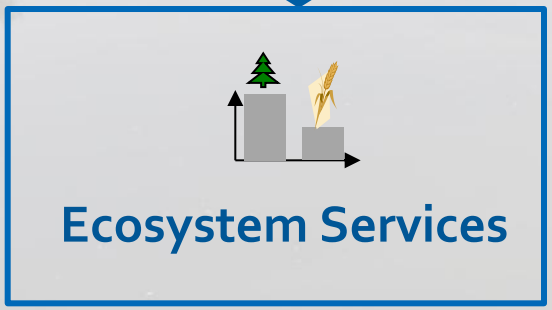
Background / Framework







Research Question

How do certain **policy instruments**
(here: afforestation)
affect **landscape structure**
and subsequently different
ecosystem services simultaneously?

Methods

Regional Stakeholders

SWAT

Goal

Minimize unintended trade-offs and natural ressources impairments by policy

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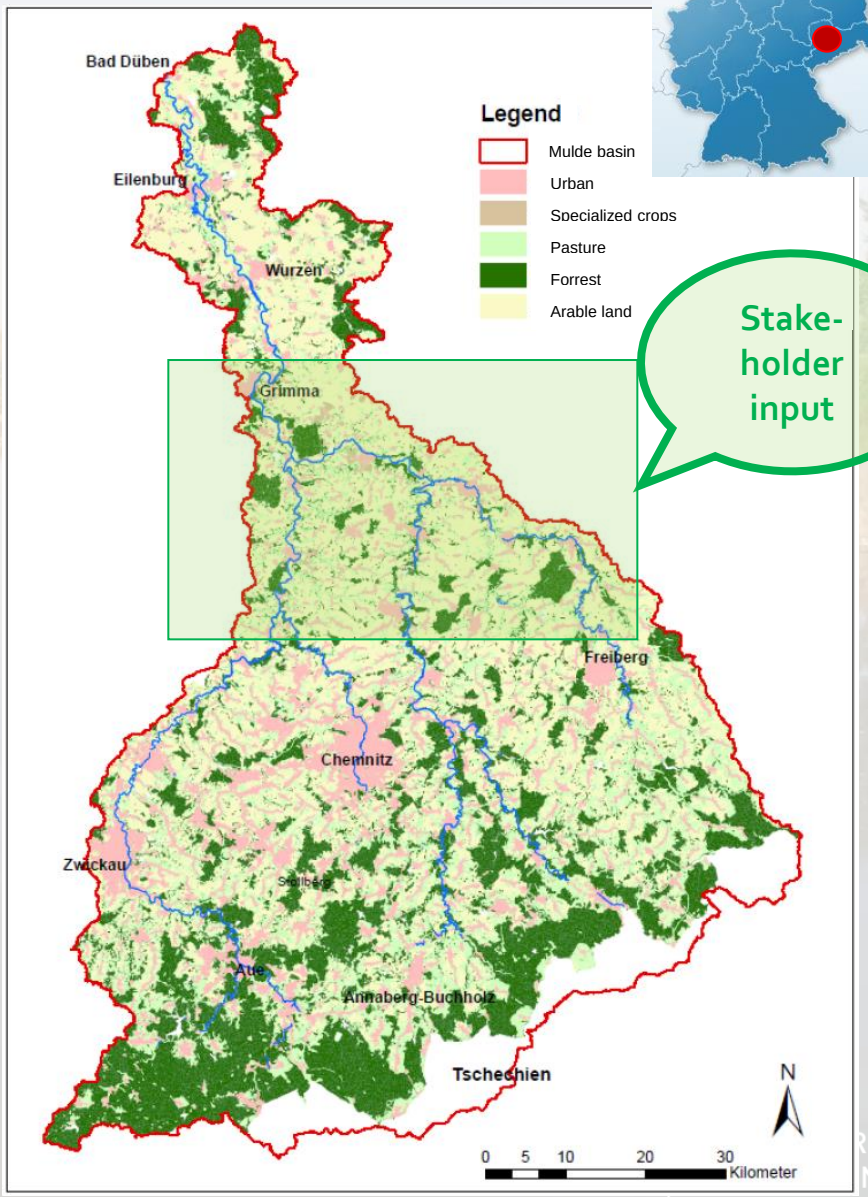
Study site

Mulde river basin (Saxony)

- ~ 6000 km²
- „Erzgebirge“, „Lösshügelland“, lowland
- Precipitation 577 – 770 mm/a
- Land use
  - Agriculture (35 % arable, 18 % pasture)
  - Forest (28 %)
  - Urban settlements (11 %)
- Protection areas (nature, water)

  ca. 43 %



Susanne Mühlner (susanne.muehlner@ufz.de)

SWAT

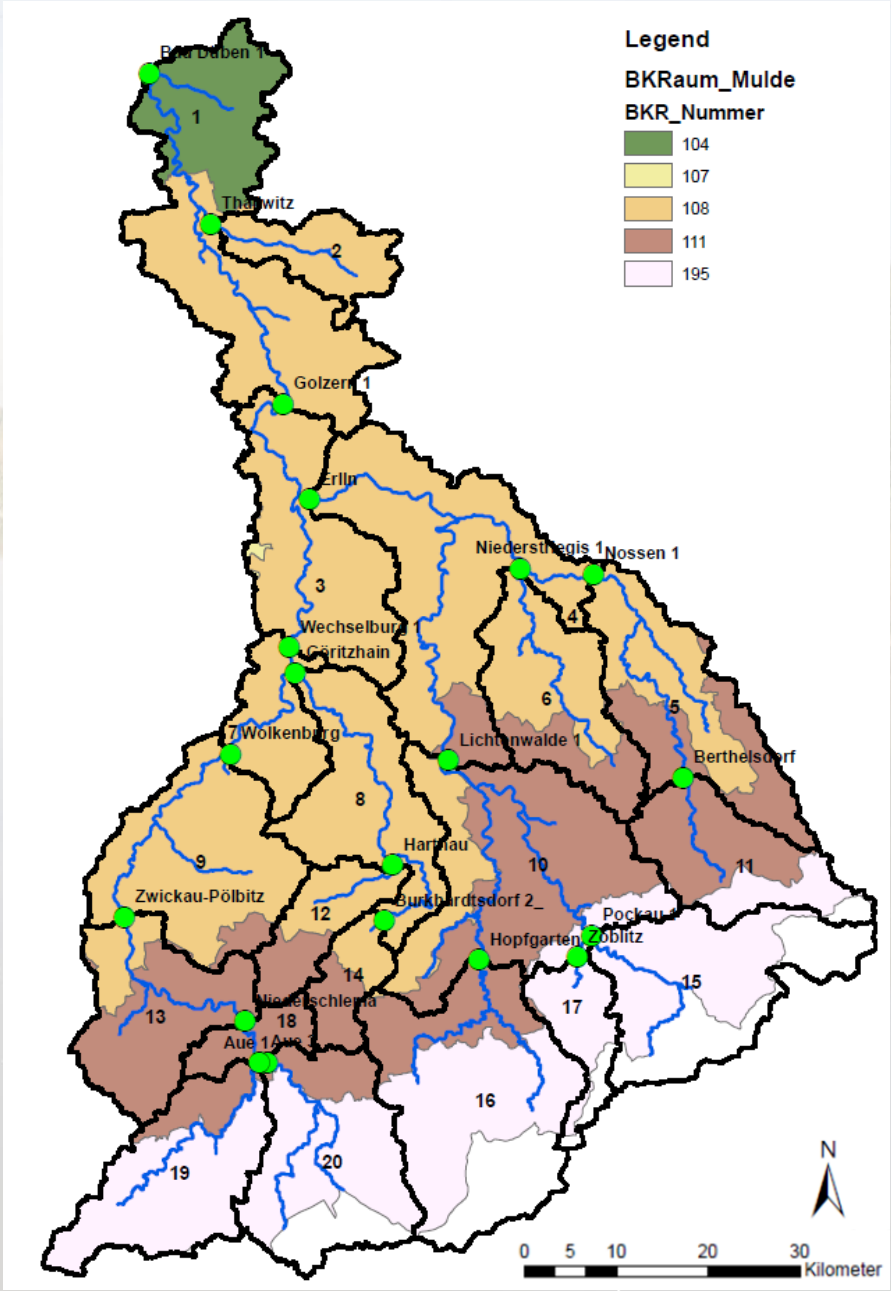
Structure

- 20 Subbasins with 760 HRU‘s
- 14 land use types based on CORINE 2006 and crop statistic 2001-2008 *(AFISS formed by Witing 2011)*
- 17 soil types
- 2 slope classes
- 4 Soil-Climate-Areas *(Roßberg et al. 2007)*
- Daily simulation

Management

- according to Abraham (2004)
- no crop rotation
- adaption of Heat Units to Soil-Climate-Area for crops and forest

Soil climate area	Heat Units FRSD
104+108 (lowland)	1233
111 (hilly)	1125
195 (mountains)	787



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SWAT

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Management

- according to Abraham (2004)
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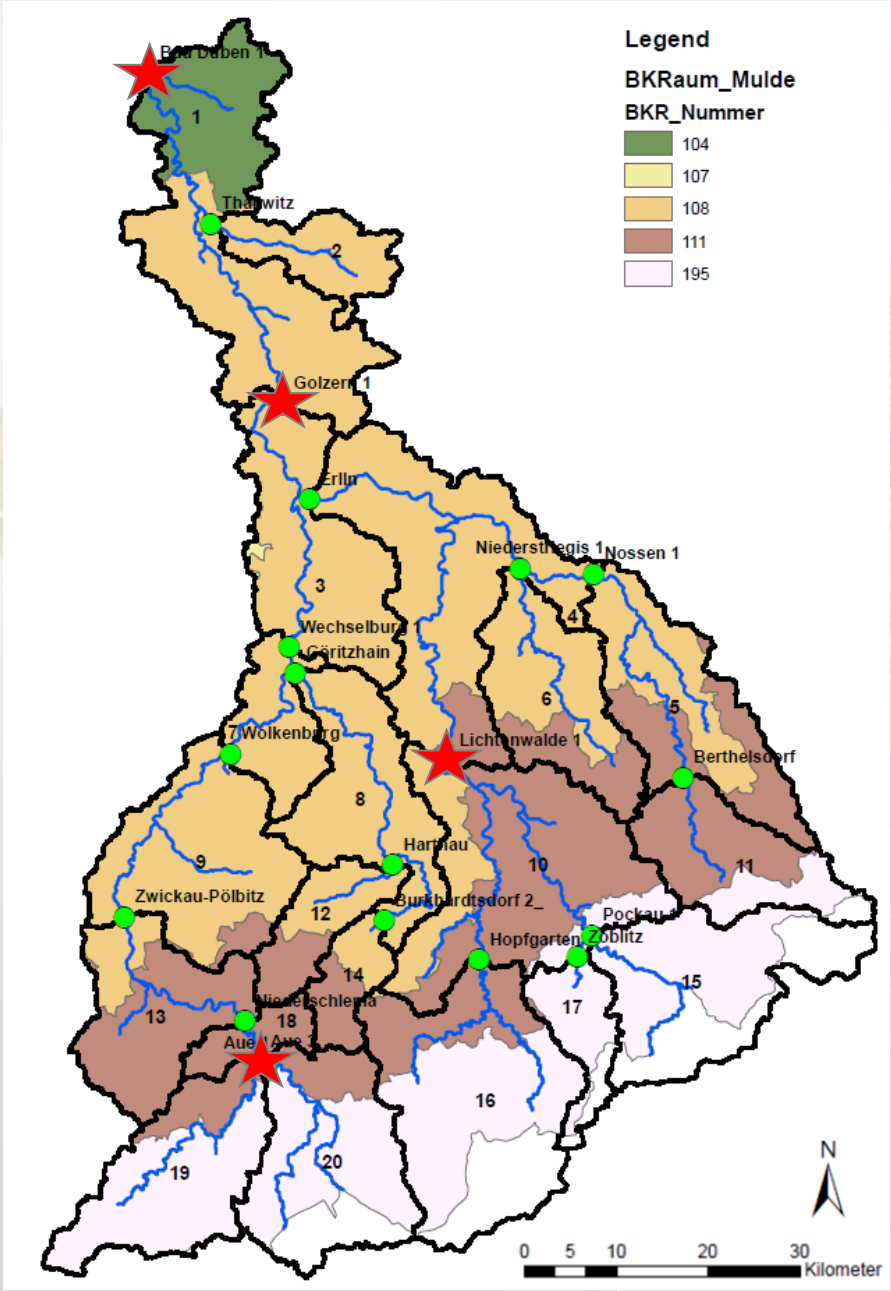
Calibration

- Multi-site calibration (4 gauges ★)
- 43 parameters (13 different parameters → 10 subbasin specific)
- SWAT-CUP (GLUE approach)



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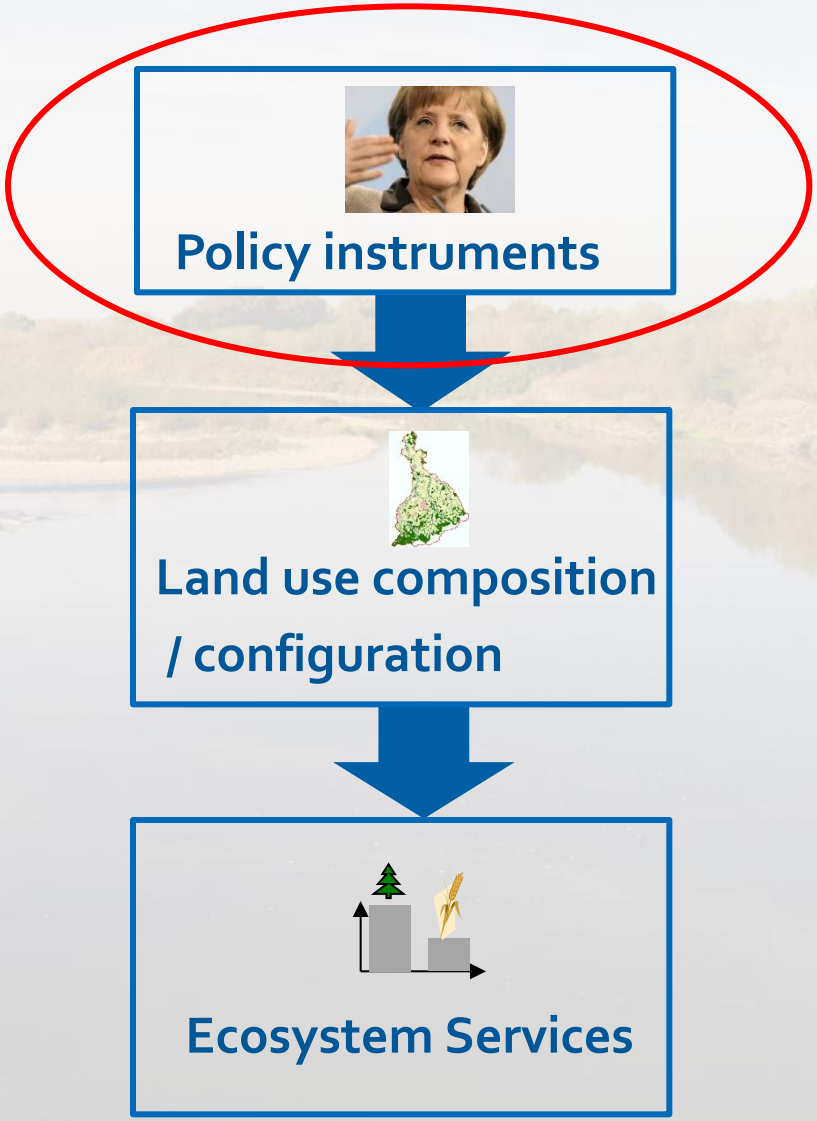
Reminder on Framework



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Policy instruments

Policy objective:

= Forest increase
in Saxony 28 % → 30 %

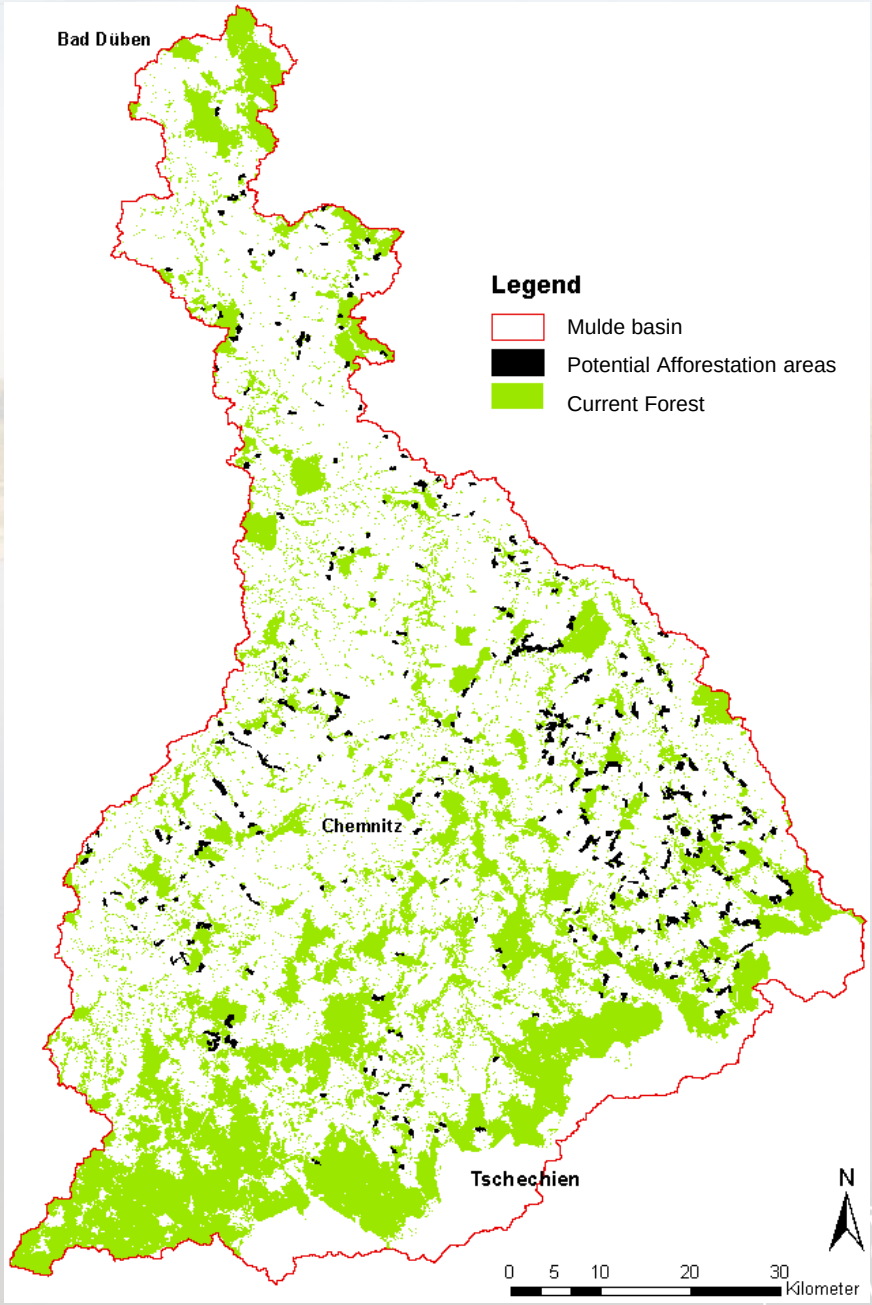
→ **Background:**
EU Agri-environmental scheme
for afforestation

Stake-
holder
input

SWAT

Landuse update tool (lup.dat)

With different scenarios for afforestation



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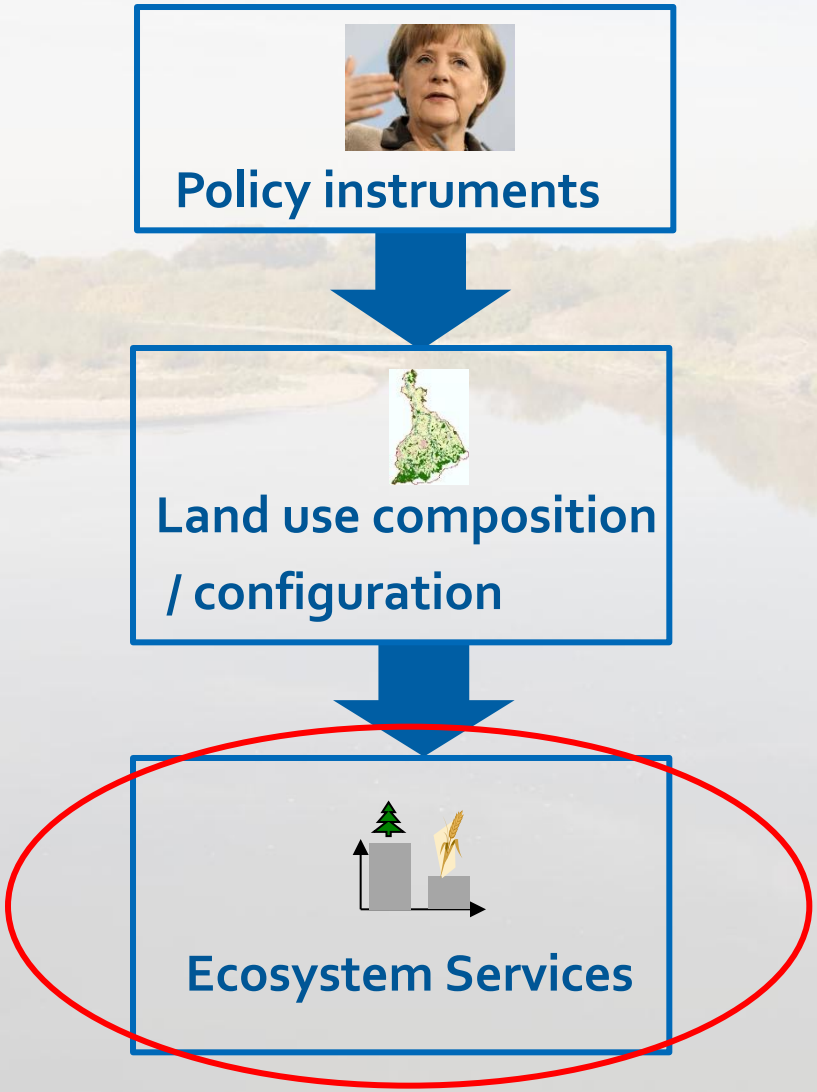
Reminder on Framework



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Ecosystem services

Ecosystem services	Indicators	SWAT file (column)
Timber provision	Yield / Biomass of timber	output.hru (Biomass)
Food provision	Yield of food crops	output.hru (Yield)
Bioenergy provision	Yield of bioenergy crops	output.hru (Yield)
Water regulation	Q5 and Q95	output.rch (Flow_out)
Fresh water provision	NO_3 concentration / load	output.rch (NO3_out)

SWAT

Stakeholder input

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Evaluation / Analyses

versus	
Perception on affected ecosystem services	Model results on affected ecosystem services
Perception on afforestation efficiency	Model results on afforestation efficiency

→ Do the model show **any** significant effect of afforestation on ecosystem services?

→ Can the model improve the public **positive** aspects of afforestation drawn by policy?

→ Do the model show **synergies or trade-offs** between the analysed ecosystem services during afforestation?

RESULTS coming soon!

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Outlook

Policy instruments

Land use composition / configuration

Ecosystem Services

Support Landscape management strategies

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Thank you for your attention!

Acknowledgements

Working group:

Martin Volk

Sven Lautenbach

Michael Strauch

Felix Witing

Friedrich Koch

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References

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Stakeholder Interviews

5 personal Interviews between October 2012 and January 2013

Organization
Regional planning association west Saxony (Leipzig)
Regional planning association Chemnitz and southwest Saxony (Zwickau)
Nature park Muldenland e.V. (Grimma)
Nature conservation organization BUND Saxony – Friends of the Earth (Chemnitz)
Forest organization of Saxony - Forest district Leipzig (Leipzig)

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Stakeholder Interview - ?Questions?

1. Relevance of ESS

1.1 Which ESS can be seen as most important / less important for the study area?

1.2 Could you name more relevant ESS important for the study area?

1.3 Which ESS will become more important / less important for the study area when the status quo of current policy instruments will be kept in the next years?

1.4 Could you tell us some boundary values for the named ESS (modeling approach)?

2. Relevance of policy instruments

2.1 How useful / necessary / efficient are current policy instruments to support the named ESS?

a) Do you see any cross-purposes between ESS affecting policy instruments and biodiversity conservation?

b) Do you see any synergies / potentials?

c) How do you think could policy instruments be improved?

2.2 Do you already percept landscape impacts of policy instruments within the study area?

3. Relevance of regions

3.1 Do you think that the above discussed aspects are dependent on specific regions within the study area?

3.2 Where do you think are the most conflicting regions within the study area and therefore most interesting to undertake our inquiry with local people?

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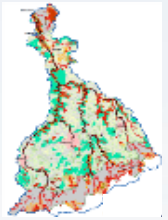
Land use Optimization

Political constraints

Current land use configuration / composition



New land use solutions

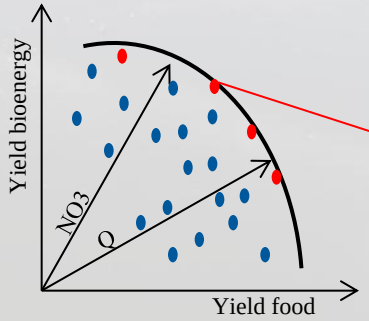
Optimization
(Genetic Algorithm)

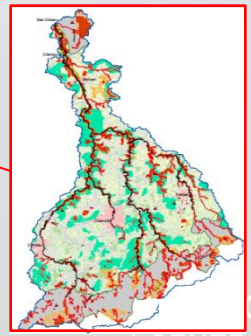
Models (SWAT, …)
→ Ecosystem Services & Biodiversity

Fitness value

Abort criterion

- ✓ ***Pareto optimal solutions***
- ✓ ***Trade-off and synergy detection***
- ✓ ***New (unexpected) functional relationships between ESS & Biodiversity***





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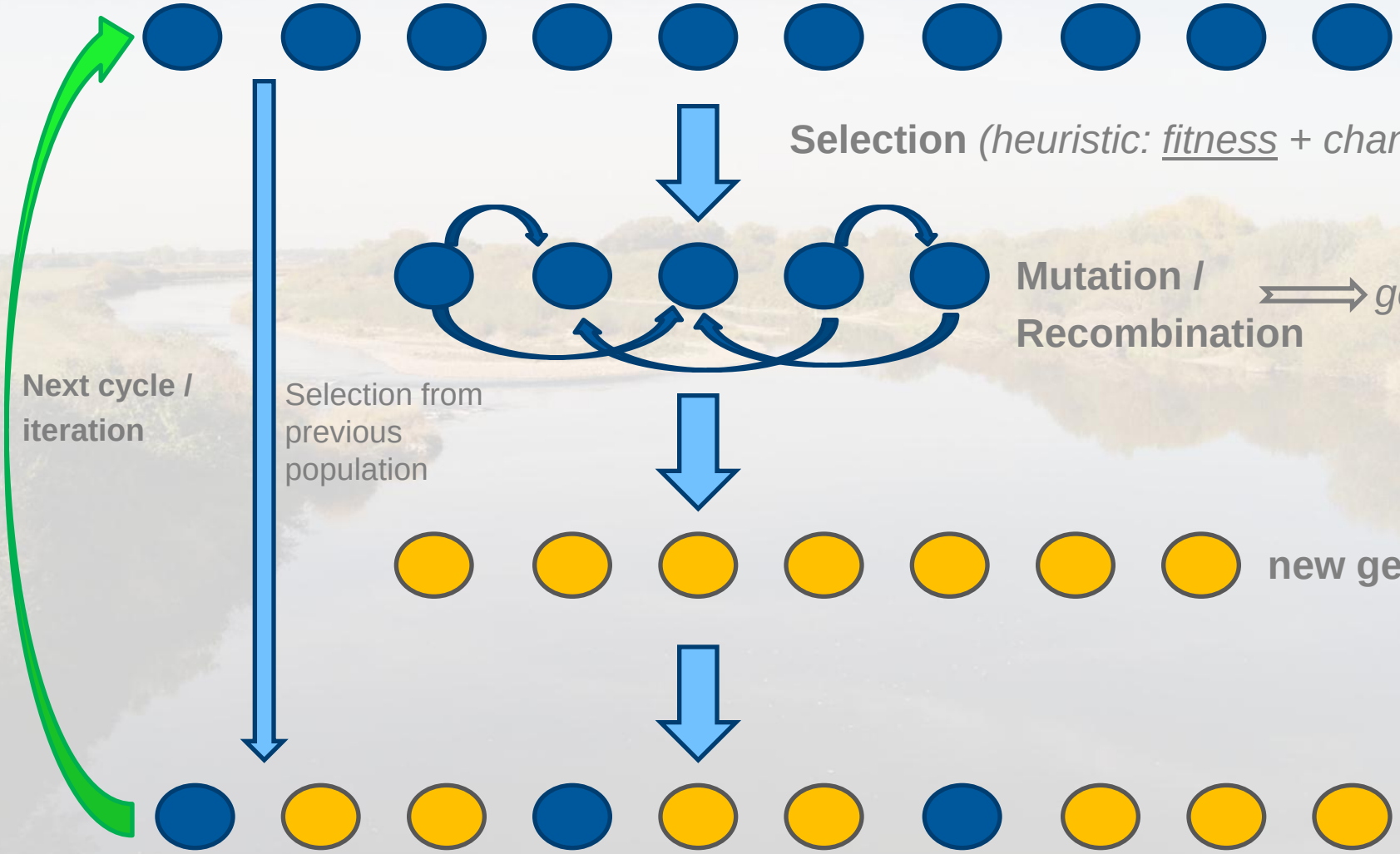
Genetic algorithm



Ecosystem services & Biodiversity

Ecosystem services	Indicators	Models (UFZ Dept. CLE)	Valuation methods (UFZ Dept. ÖKON)
Timber production	Yield of timber	SWAT	Market value
Food production	Yield of food crops	SWAT	Market value
Bioenergy production	Yield of bioenergy crops	SWAT	Market value
Water quantity	Q5 and Q95	SWAT	Choice Experiment
Water quality	NO_3 concentration / load	SWAT	Choice Experiment
Carbon sequestration	Stored C-value per unit	LPJ	Market value
Landscape aesthetics	Landuse configuration / composition	Choice Experiment	Choice Experiment
Biodiversity	Species abundance per unit	GLM	Choice Experiment

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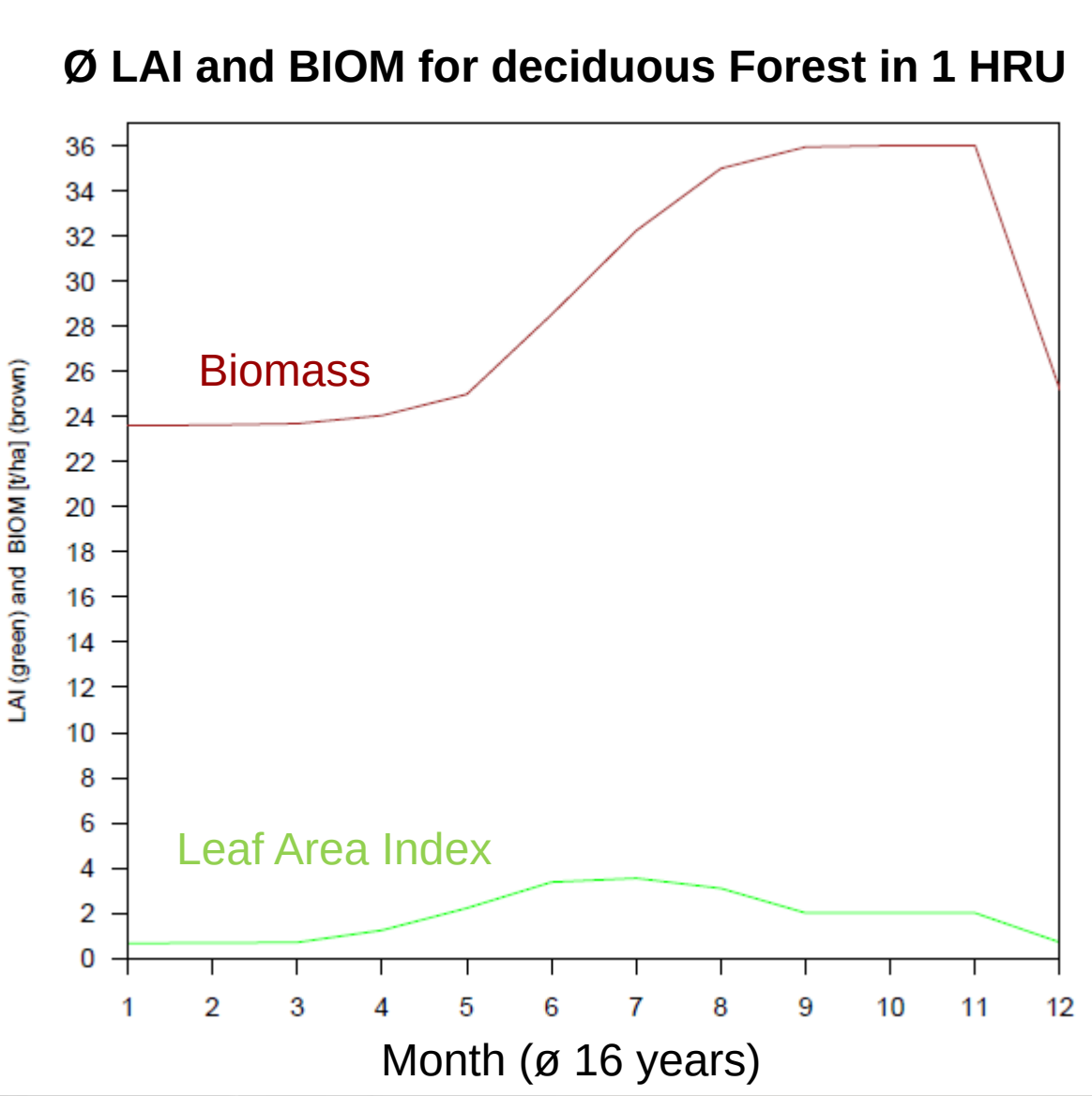
Current model Forest growth (Deciduous Forest) based on PHU



Soil climate area	PHU
104+108 (lowland)	1233
111 (hilly)	1125
195 (mountains)	787

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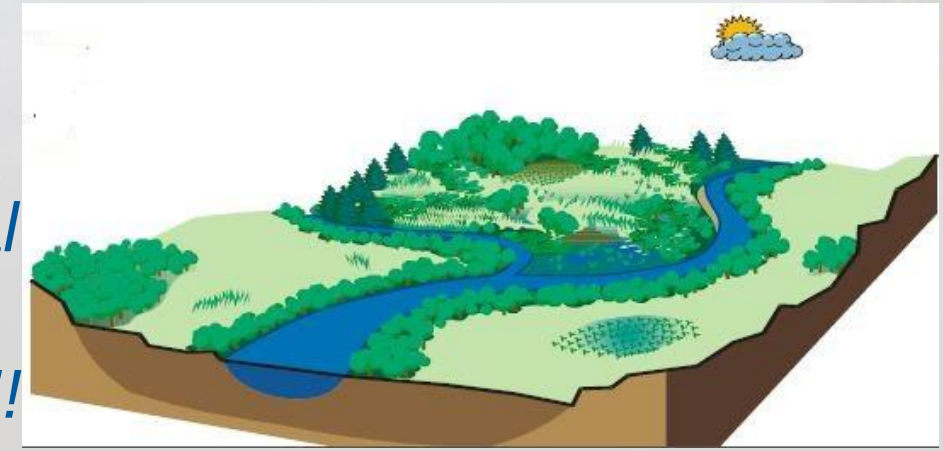
Objectives of SWAT

- Simulation of processes at land and water phase
- Spatially distributed (different scales)
- Semi physically based / empirical approaches
- Simulation of changes (climate, land use, management etc.)
- **Water quantities**, incl. different runoff components
- **Water quality**: Nutrients, Sediments, Pesticides, Bacteria, (algae and oxygen), etc.

…. all that on a daily time step and at different spatial scales and (more or less) readily available data sets!!



SWAT structure