Finding a regional balance between land pressures:

Timber/food versus bioenergy versus sequestration

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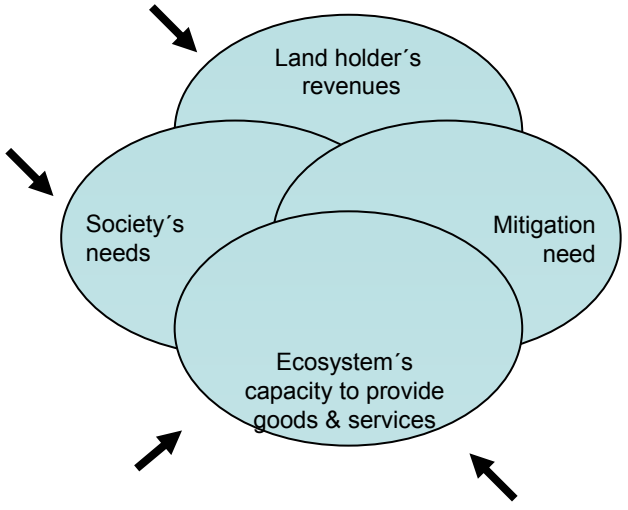
Opportunities and boundaries



Outline

- Bioenergy
- Thuringian Case study
  - Agriculture (cropland)
  - Forestry
- Generalisation

Which option is most climate-friendly?

- Sequestration
  - Mean residence time
  - Risks
  - Leakage (timber/energy)
  - Biodiversity, amenity
- Production
  - C stocks in forest and products
  - Mean residence time
  - By-products
  - Recycling
- Bioenergy
  - Substitution effectiveness
  - Leakage (timber)

Climate effects of energy substitution

- Theory of „climate neutrality“ of renewable energy
- Assumptions
  - Sustainable production
  - C stocks constant at large scales
  - Small GHG emissions and fossil fuel consumption during production

    TRUE?

  - Byproducts irrelevant or useful

    TRUE.

- Reality: check by life cycle assessment

Bioenergy

- Substitution effectiveness =
  t fossil-C saved per t bioenergy-C
- Regional substitution effectiveness =
  proportional substitution of current fossil energy mix with modern technology
- Life cycle assessment
  - Reference unit: useable energy
  - Typical combinations of fossil energy carriers and energy conversion technology

Case study: Thuringia

- Agriculture
  - Plains
  - Rich soils
- Forest
  - Low mountain ranges
  - Poor soils
- Afforestation of agricultural land is possible, but not cultivation of forests

C stocks and fluxes

- C stocks
  - Biomass
  - Soil + Litter
  - Products
- C fluxes
  - C stock changes in biomass, soil + litter, products
  - Net CO_2 substitution effect of bioenergy

Boundary conditions

- Forest:
  high average C stocks = moderate C sink potential
- Cropland:
  low average C stocks = high C sink potential
- Land management criteria
  - Do not deplete average (time/space) C stocks
  - Continued management without intensification
  - Systems with low risk of non-management disturbance

Cropland:
Imagine a hectare of cereals…

- Food only
- Food + straw
- Set-aside
  - Annuals
  - Poplar
  - Afforestation

- What will pay off most?

Cropland management alternatives in Thuringia

System	Main product	Rotation (years)
Triticum cropland, food	Food grains, straw remains on site	1
Triticum cropland, food + straw energy	Food grains, straw for energy	1
Populus set-aside, energy	100% wood for energy	3x5
Quercus afforestation of set-aside cropland	Timber (sawnwood, pulp, energy; 80% of sawnwood and pulp recycled for energy)	200

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Thuringia, 2000: Substitution effectiveness

t fossil-C saved per t bioenergy-C

Heat plant. natural gas	Combined heat and power plant. natural gas	Heat plant. light heating oil	Power plant. lignite	**Regional substitution effectiveness in Thuringia**
Winter wheat, whole crop	0.36	0.54	0.75	0.49
Winter wheat, straw	0.45	0.67	0.92	0.61
Scaling fraction	0.27	0.11	0.17	

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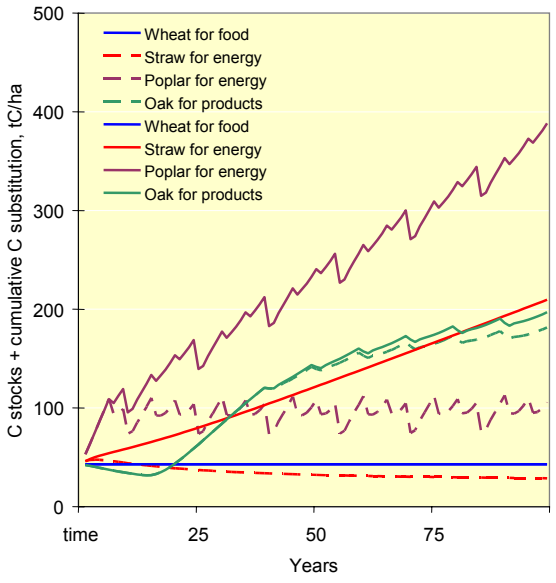
Results: Climate effects in cropland

1 ha of cropland



Mean C stocks (t C/ha) over 150 years

168 → 303

98 → 153

43 → 43

28 → 168

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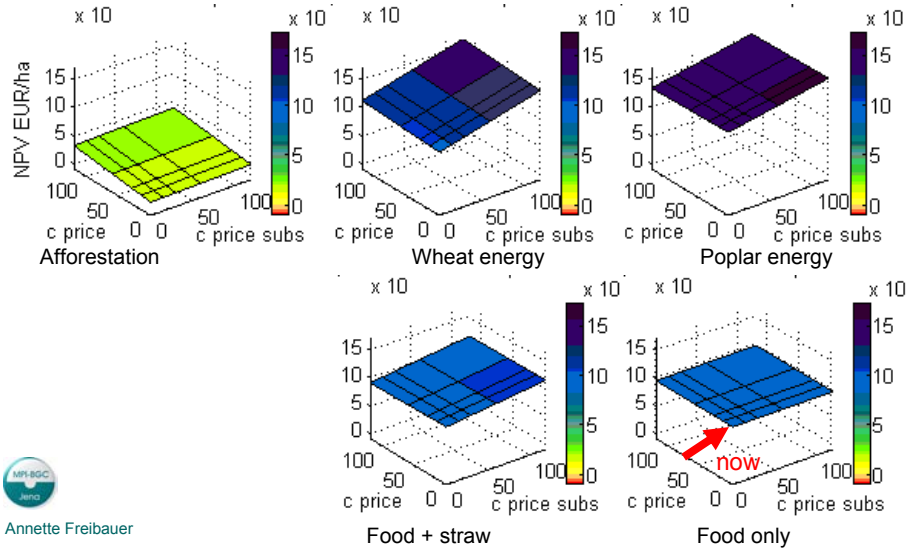
Does it pay off?

- Cropland (at present subsidies)



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Forestry:
Imagine 1 hectare of land …

- Poor soil or slope
- Previously forest
- Unsuitable for crops

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Land holder´s decisions

- Continue timber production
- Switch to bioenergy
- Sequester carbon on-site

- What will pay off most?

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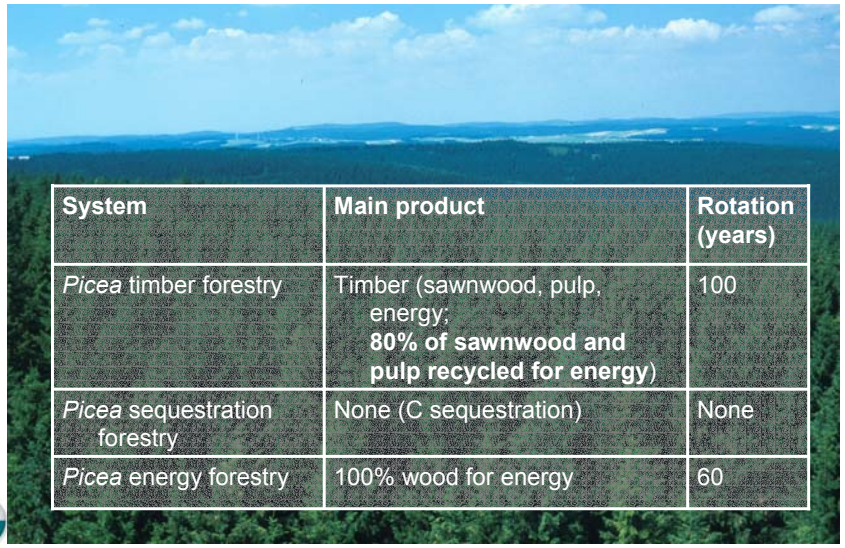
Forest management alternatives in Thuringia



System	Main product	Rotation (years)
Picea timber forestry	Timber (sawnwood, pulp, energy; **80% of sawnwood and pulp recycled for energy**)	100
Picea sequestration forestry	None (C sequestration)	None
Picea energy forestry	100% wood for energy	60

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Thuringia, 2000: Substitution effectiveness

t fossil-C saved per t bioenergy-C

	Combined heat and power plant with natural gas	Heat plant with light heating oil	Power plant with lignite	**Regional substitution effectiveness in Thuringia**
Spruce wood for energy	0.44	0.63	0.87	0.57
Spruce, slash	0.45	0.65	0.89	0.61
Scaling fraction	0.27	0.11	0.17	

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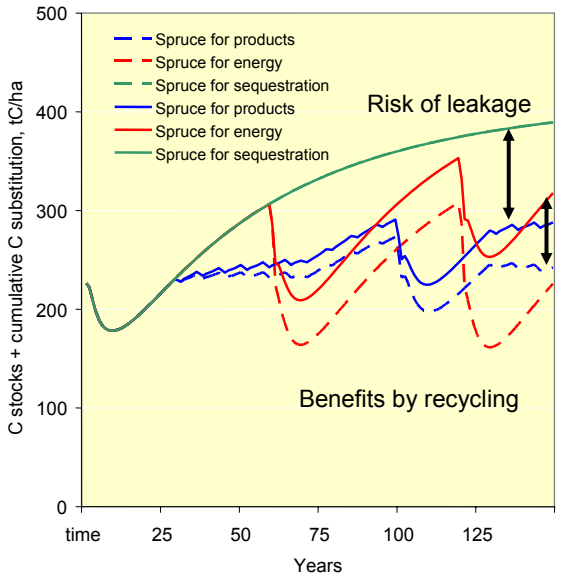
Results: Climate effects in forestry

1 ha of spruce forest



Mean C stocks over 150 years (t C/ha)

311 → 311

229 → 246

226 → 262

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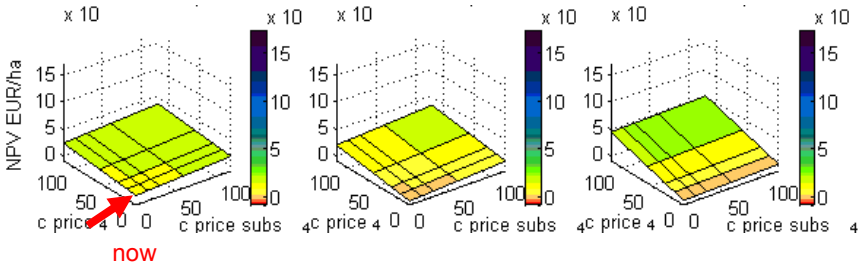
Does it pay off?

- Spruce forest



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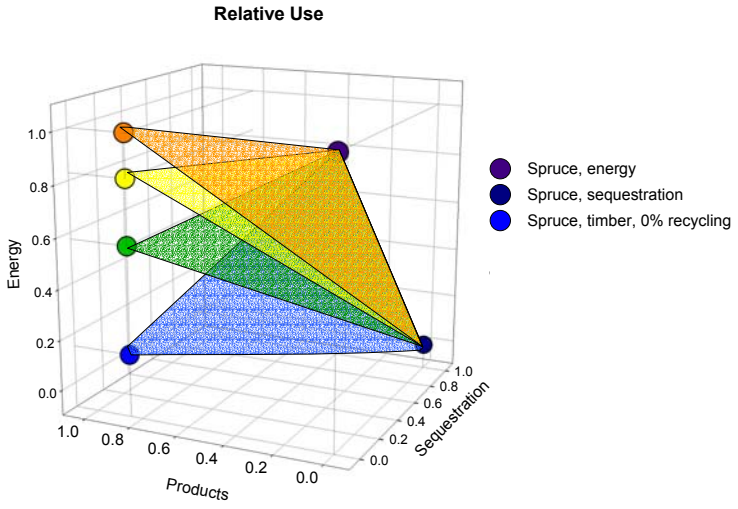
Services from a hectare of forest land



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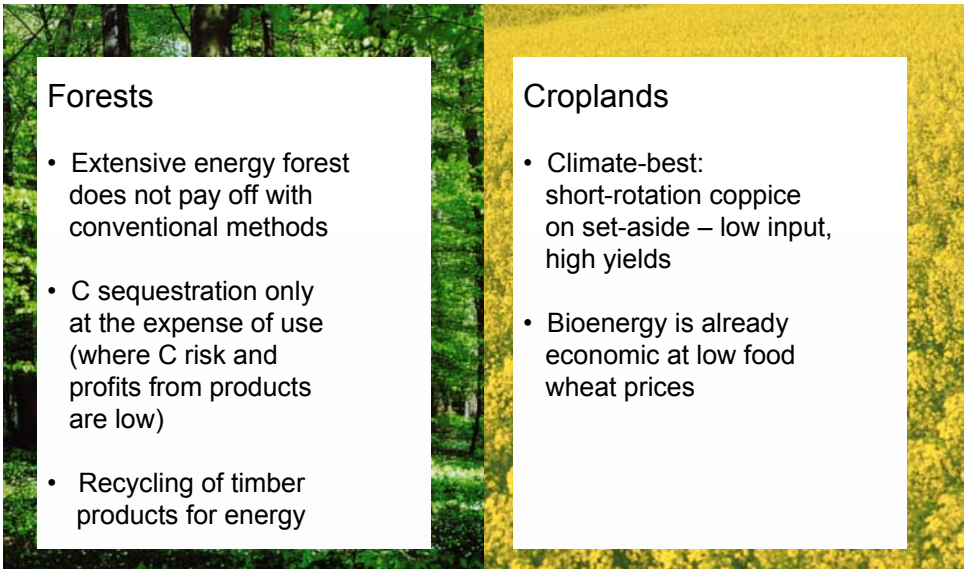
Conclusions of Thuringian Case Study



Forests

- Extensive energy forest does not pay off with conventional methods
- C sequestration only at the expense of use (where C risk and profits from products are low)
- Recycling of timber products for energy

Croplands

- Climate-best: short-rotation coppice on set-aside – low input, high yields
- Bioenergy is already economic at low food wheat prices

What if…

- Climate is dry?
  - Fire risk: Use residues
  - Need for irrigation: High-value products
- Land pressure is high?
  - Long product chains
- C sequestration produces leakage due to intensified production elsewhere at constant demand?

Conclusions

- Land and ecosystem productivity are more limited than human creativity to make effective use and recycle products
- Mitigation in the LULUCF sector cannot work effectively without considering indirect climate effects by substitution and leakage
- Effective product recycling can free land for new services, e.g. sequestration, without increasing land use intensity