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WAB (Wetenschappelijk Assessment en Beleidsanalyse klimaatverandering):

Global biomass potentials and their links to food, water, biodiversity, energy demand and economy

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ECN
Energy research Centre of the Netherlands

uce
Utrecht Centrum voor Energie-onderzoek
Utrecht Centre for Energy research

Background

- Growing interest for (modern) biomass for energy & materials
- Strong disputes about magnitude of (sustainable) potentials

- Role of biomass in future energy & material supply?
  - Limitations (water, land)
  - Competing demands (food, feed, fuel)
  - Biodiversity impacts
  - Competing options (energy supply, GHG emission reduction)

Research objectives

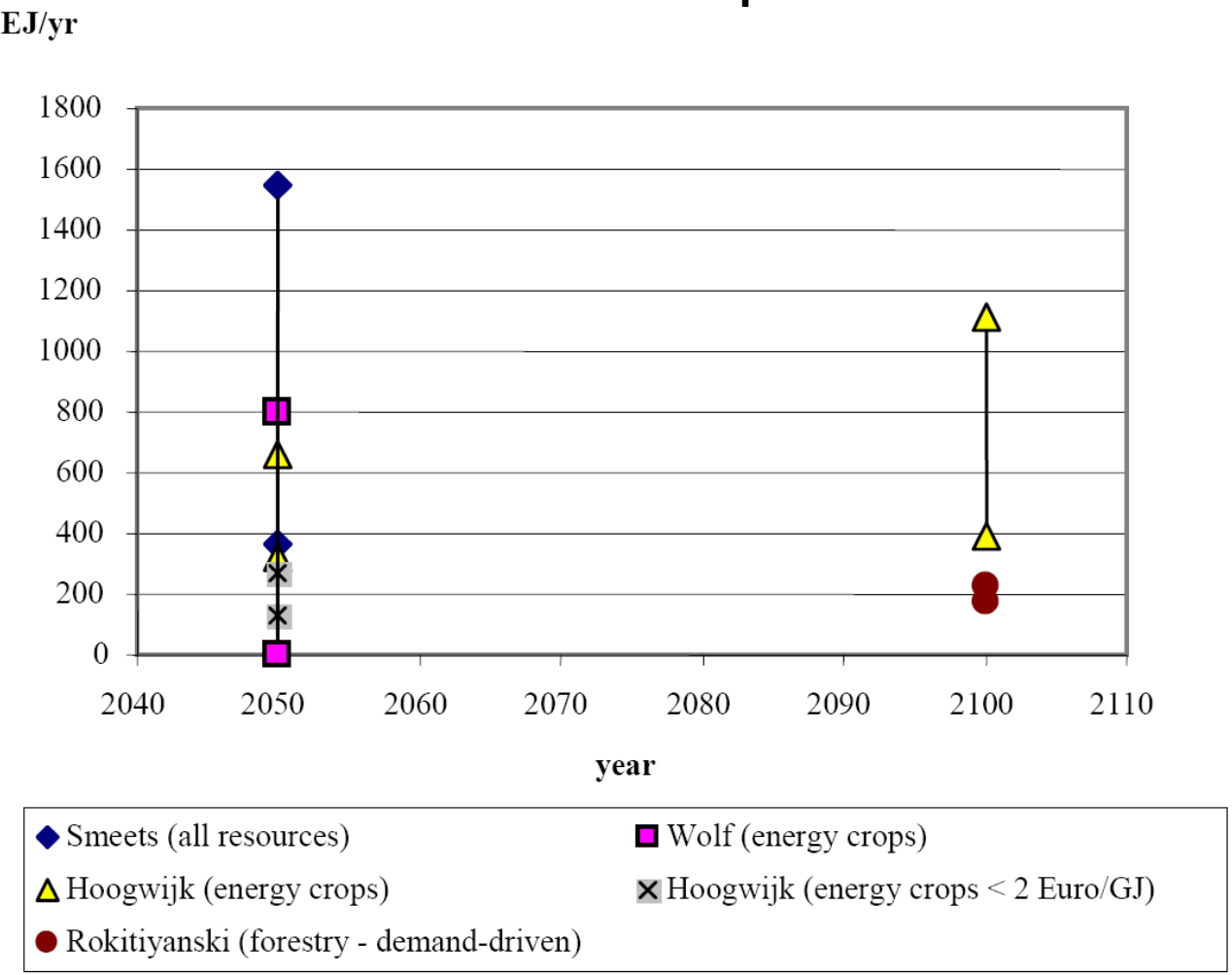
- Insight in links between biomass for energy and:
  - Food supply
  - Water use
  - Nature & biodiversity
  - Economic mechanisms
  - Energy system
- Not included:
  - social, legal and institutional aspects
- Overview knowledge, knowledge gaps and their impacts
- Policy recommendations for biomass development

Approach

1. Inventory of scientific knowledge in various fields and their links:
   - Global biomass potentials, food, water, biodiversity, agricultural economics and energy demand
2. Integration:
   - Additional quantitative analyses
   - Qualitative discussion
3. Conclusions, recommendations

1. Inventory

Global biomass potentials – recent studies



Differences in:

- Agricultural productivity
- Food demand

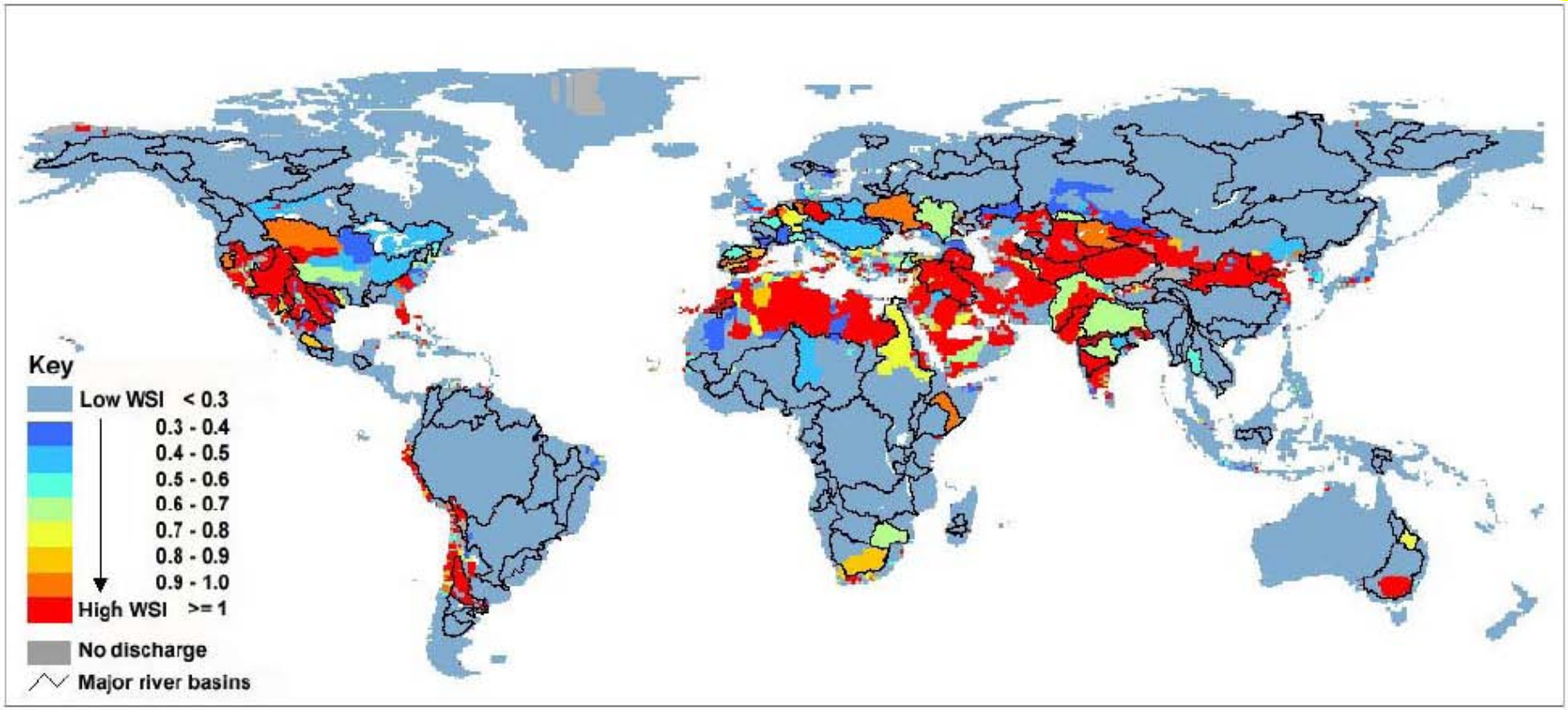
Weak inclusion of:

- Water limitations
- Dev. human diet
- Wood demand
- Biodiversity objectives

Biodiversity in current biomass assessments

- Exclusion of land areas for the production of biomass (technical potentials)
  - land exclusion: all, protected areas, forest land
- Assumption of low-intensive production systems
  - Low intensive forestry
  - Constant use of pastures Low-intensive agricultural production system
- None of the regarded potential studies evaluates the effect of biomass production on biodiversity.

Water



- Some regions abundant water availability, but also many (potentially) stressed areas
- Detailed assessment on local (water basin) level needed
- Changing rainfall patterns due to climate change => net effect?

Biodiversity

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⇒Results of studies on biodiversity effects of growing bio-energy crops are very diverse

- Possible indicators imperfect to capture full complexity of biodiversity
  - Different indicators => different messages
    (e.g. “naturalness” versus “agro-biodiversity”)
- Local impact

  +: replacing intensive agricultural systems by extensive perennial crops

  +: replacing mono-cultures by mixed systems (agro-forestry, mixed cropping, organic farming).

  -: Conversion of areas with high biodiversity
  (natural areas, extensive agricultural production)
- Global impact
  - Balance land-use change versus climate change mitigation
    (often negative, ~ developments in the agricultural sector)

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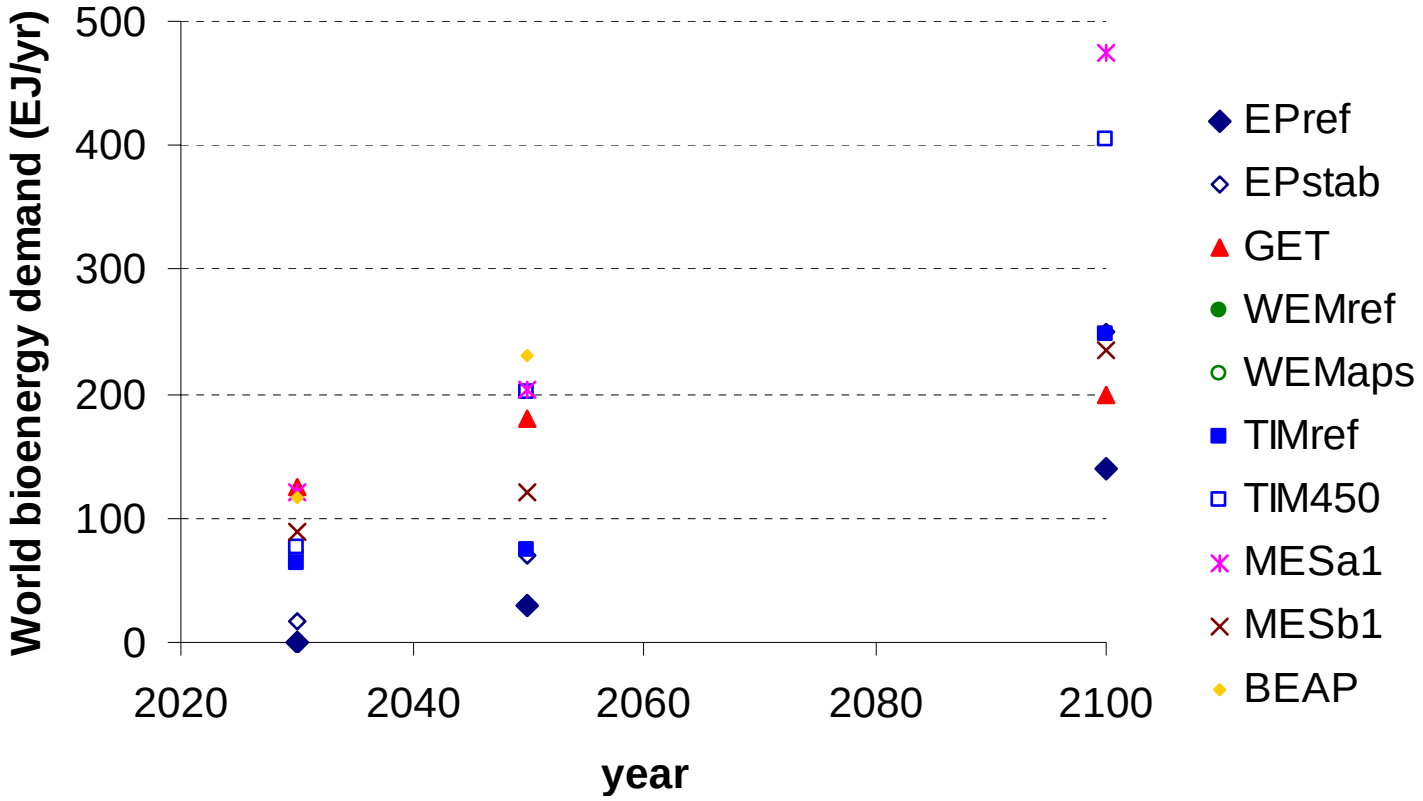
Food and diets

- All potentials based on FAO projections
  - Best available, but crude
- Knowledge gap: consumer preferences on diet change:
  - Cultural trends, status
- Replacing animal protein by plant protein could increase land availability

Demand for biomass for energy



Differences:

- Biomass cost – supply
- Other technology options

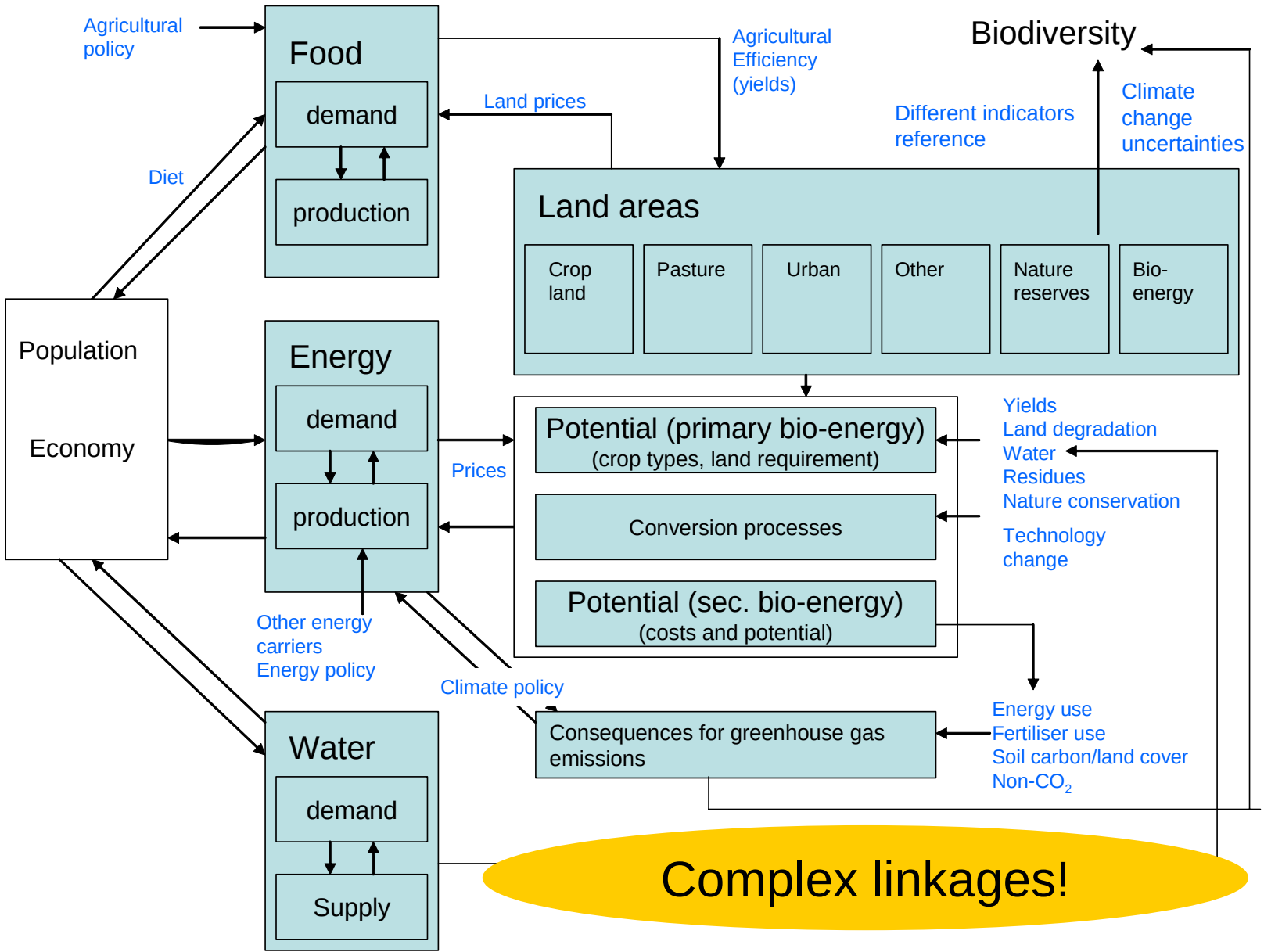
Poor coverage of:

- Material applications poor
- Constant costs for biomass
- Technological learning?

Agricultural economics

- Bioenergy now being included in models (1st generation)
- Magnitude of agricultural product price changes varies in different models
- EU-biofuel directive will have strong impact on agricultural production and land use in Europe and outside Europe
- Macro-economics and consumer choices direct bioenergy developments

2. Integrating the linkages

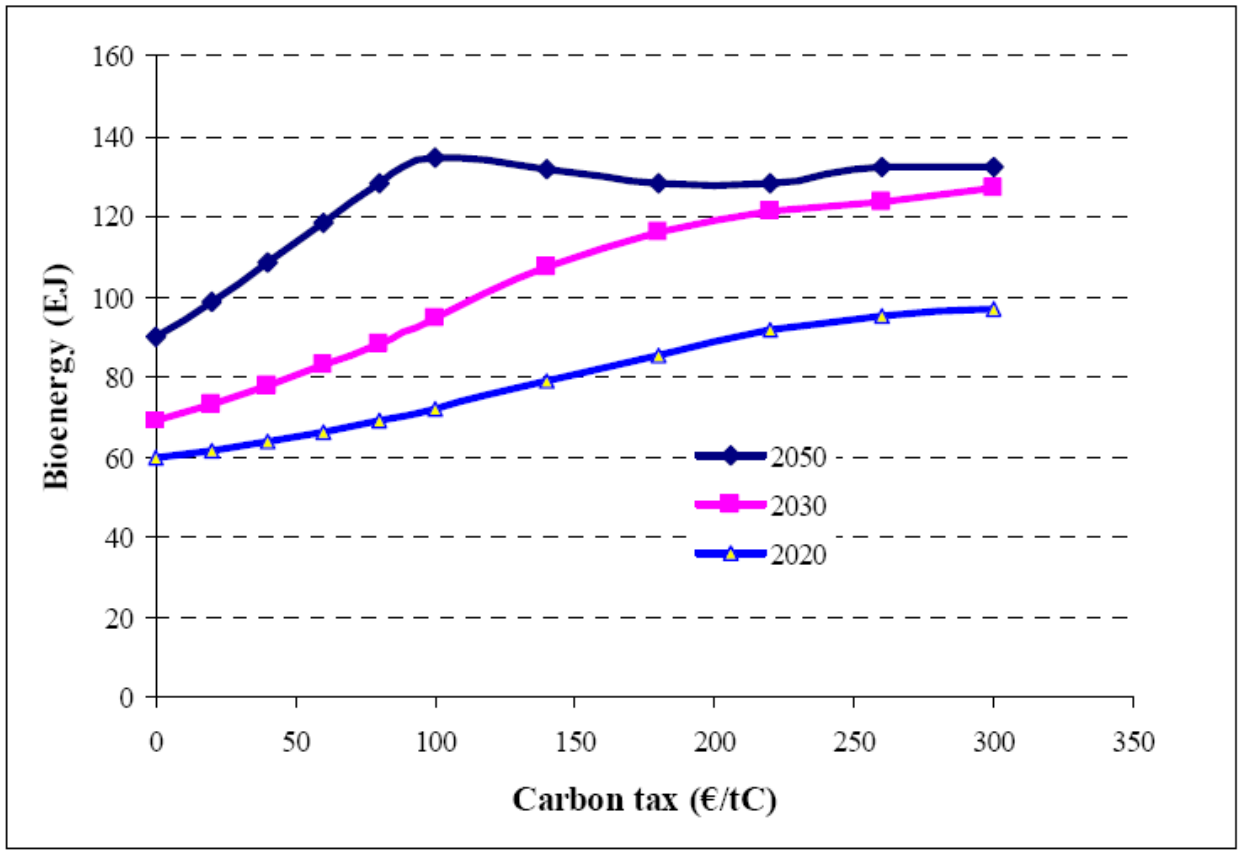


Complex linkages!

Additional modelling

- Biomass use: supply or cost the limiting factor?
  - MARKAL, TIMER
- Impacts of technology learning (MARKAL)
- Impacts on potentials (IMAGE) of:
  - Variations in agricultural yields
  - Water limitation
  - Land degradation
  - Biodiversity reserves
- Impacts on biodiversity (GLOBIO)

Bioenergy use in demand-side models



1. Biomass use limited by marginal costs, not by potential.

2. Technological learning has hardly any effect on the role of bio-based options .

Limitations in degraded land, protected areas and water

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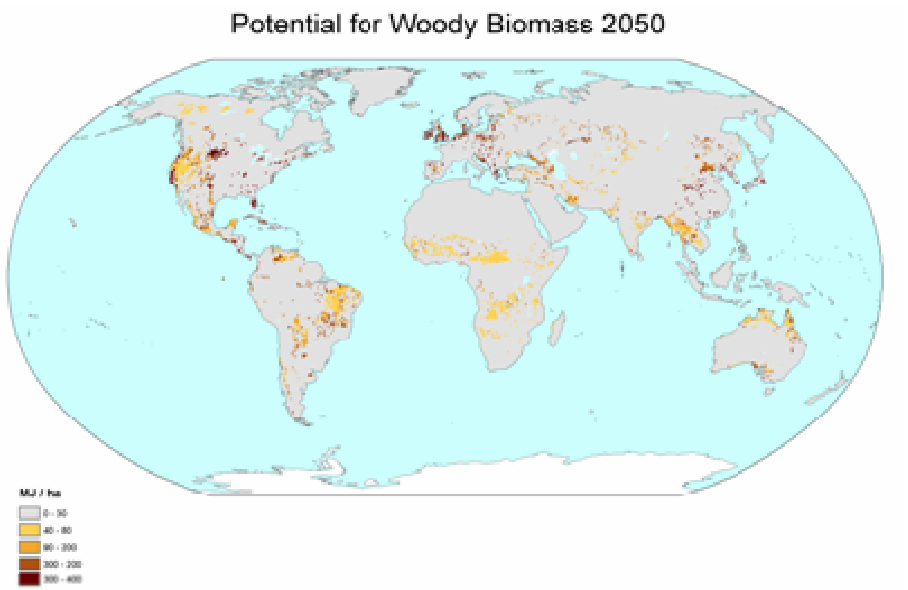
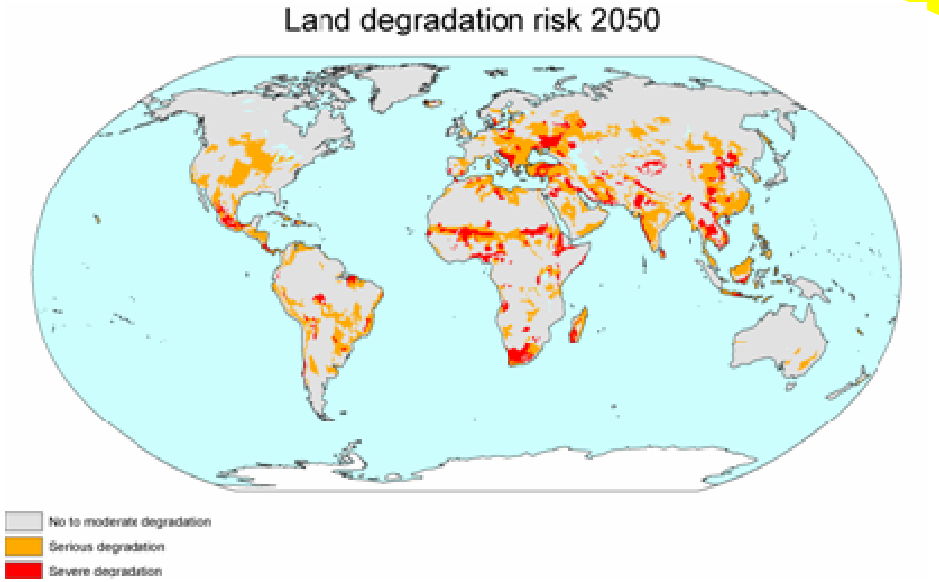
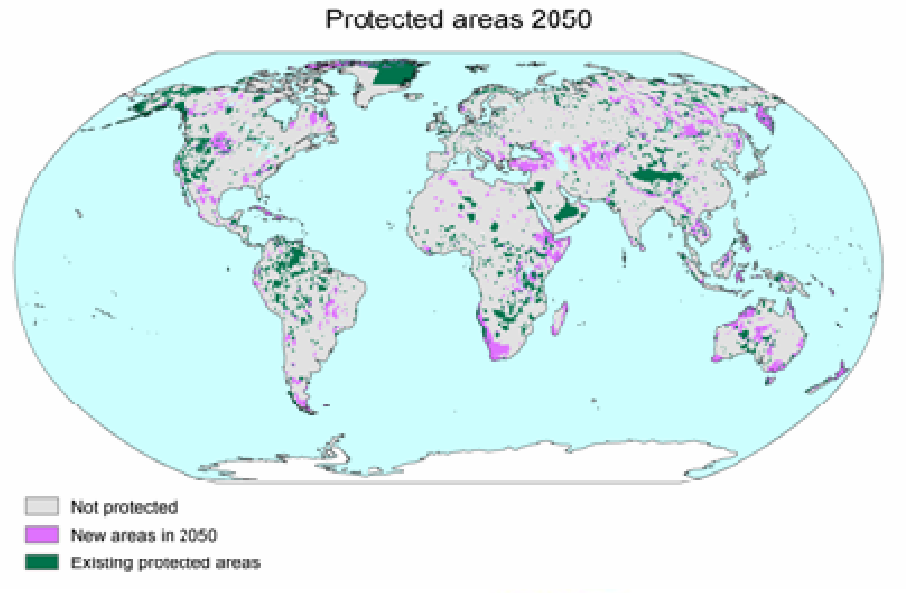
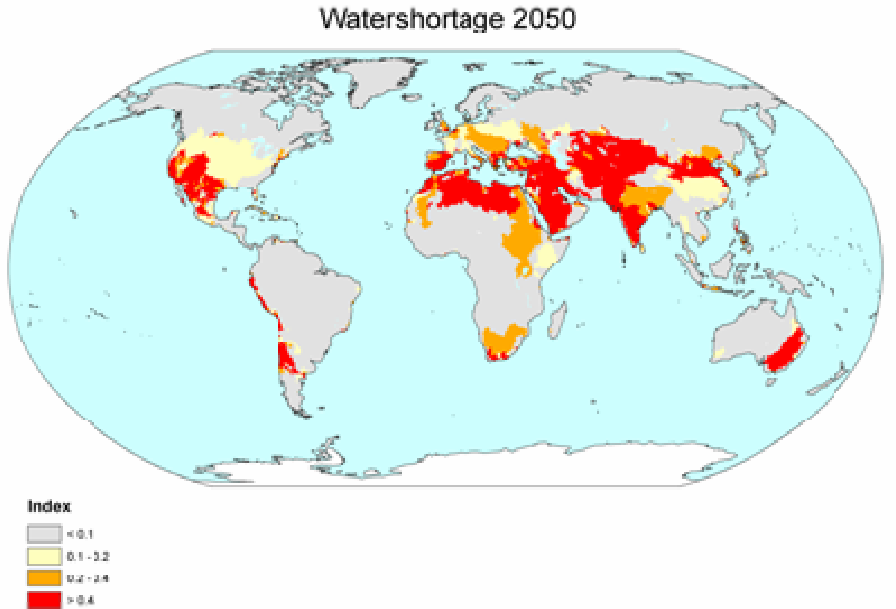
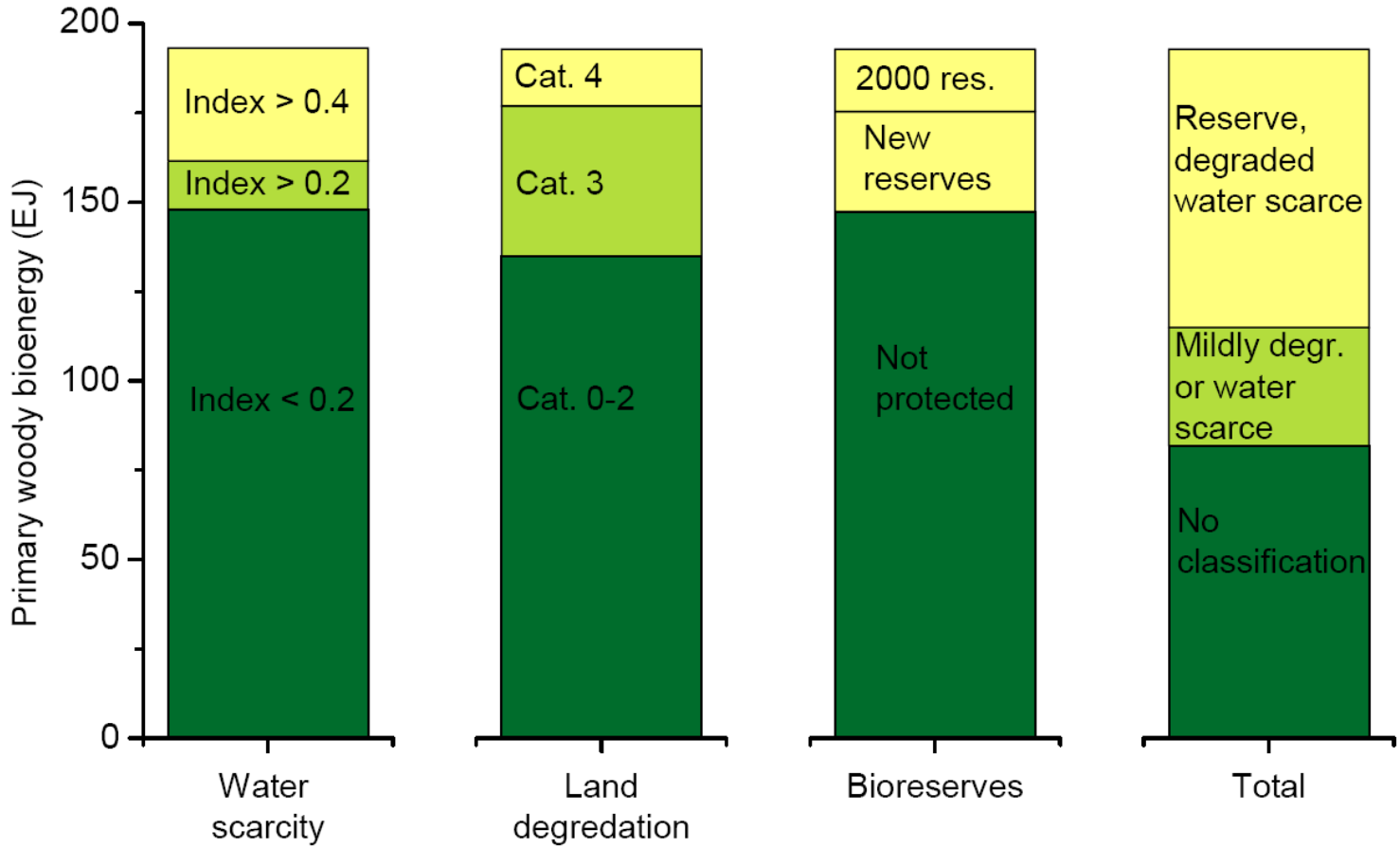








Impacts on (woody) crop potentials
(DV-2 scenario)



Biodiversity - uncertainties

	GBO2 study	OECD study	Unit
BASELINE biodiversity decline	- 7.5%	- 11%	Global MSA
OPTION 450 ppm information			
Option biodiversity effect	- 1%	+ 1%	Global MSA
Different biofuel crops: extreme variants and local biodiversity effects			
Potential biodiversity in natural area	4.6%	3.6%	Local MSA
- 1st generation biofuel crops	- 4.0%	- 3.1%	
Biodiversity response to different climate change sensitivities (ΔT in 2100)			
1.5 K	- 1,8%	- 1,8%	Global MSA
2 K	- 3,0%	- 3,0%	Global MSA
4.5 K	- 4,5%	- 4,5%	Global MSA

Uncertainties depend on:

- baseline scenario
- type of crop (Agricultural crops > perennials > agroforestry)
- type of land used (Agricultural crops > perennials > agroforestry)
- trade-off climate change
- developments agriculture (expansion, intensification, shift of areas)

Key uncertainties biomass potentials

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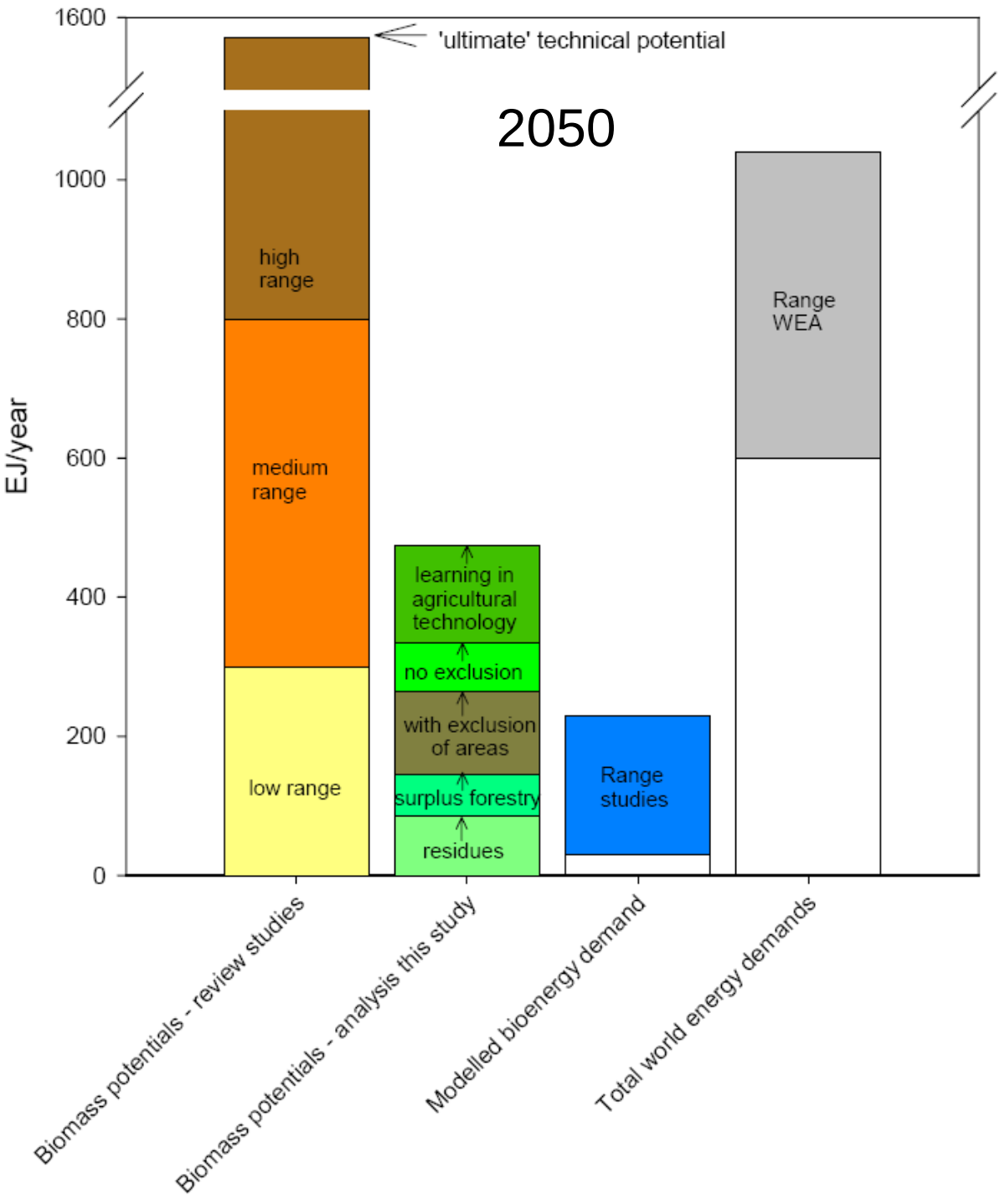
Issue/effect	Importance
Supply potential of biomass	
Improvement agricultural management	***
Choice of crops	***
Food demands and human diet	***
Use of degraded land	***
Competition for water	***
Use of agricultural/forestry by-products	**
Protected area expansion	**
Water use efficiency	**
Climate change	**
Alternative protein chains	**
Demand for biomaterials	*
Demand potential of biomass	
Bio-energy demand versus supply	**
Cost of biomass supply	**
Learning in energy conversion	**
Market mechanism food-feed-fuel	**



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3. Conclusions (1)

Biomass can play a significant role in future energy supply given technical and economic potentials

[Main range supply (100-400 EJ) higher than demand]

Conclusions (2)

- Biomass resource potentials ~ numerous factors, e.g.
  - Degraded lands (limited experience and uncertainties)
  - Water (crucial limitation in some regions; water management)
  - Human diets, protein supply
- Mixed cropping systems, perennial crops
  => better perspectives than annual food crops
  - (potentials, sustainability)
- Positive local biodiversity effects may neglect global production shifts.
- Competition food, feed, fuel important
  - price chances uncertain; feedback into agricultural efficiency?

Research needs

Many uncertainties and scientific questions, research gaps to be addressed in in a comprehensive manner:

- Integration of modelling efforts of the various arenas
- Improve knowledge on linkages and knowledge gaps

Recommendations

- Many uncertainties beyond (Dutch) policy control
- Development sustainable biomass potentials :
  - Sustainability safeguarding mechanisms
  - Modernization of agriculture (developing countries)
  - Enhancement of perennials
- Policies should incorporate a variety of targets
  => No ‘simple’ biofuels obligation!

The sustainable technical potential of biomass production is sufficient to meet economic needs in the coming decades. The societal challenge is to allocate biomass production to suitable areas and production systems.