



BIOENERGY PRODUCTION AND ECOSYSTEM SERVICES CONSERVATION IN THE ALPS

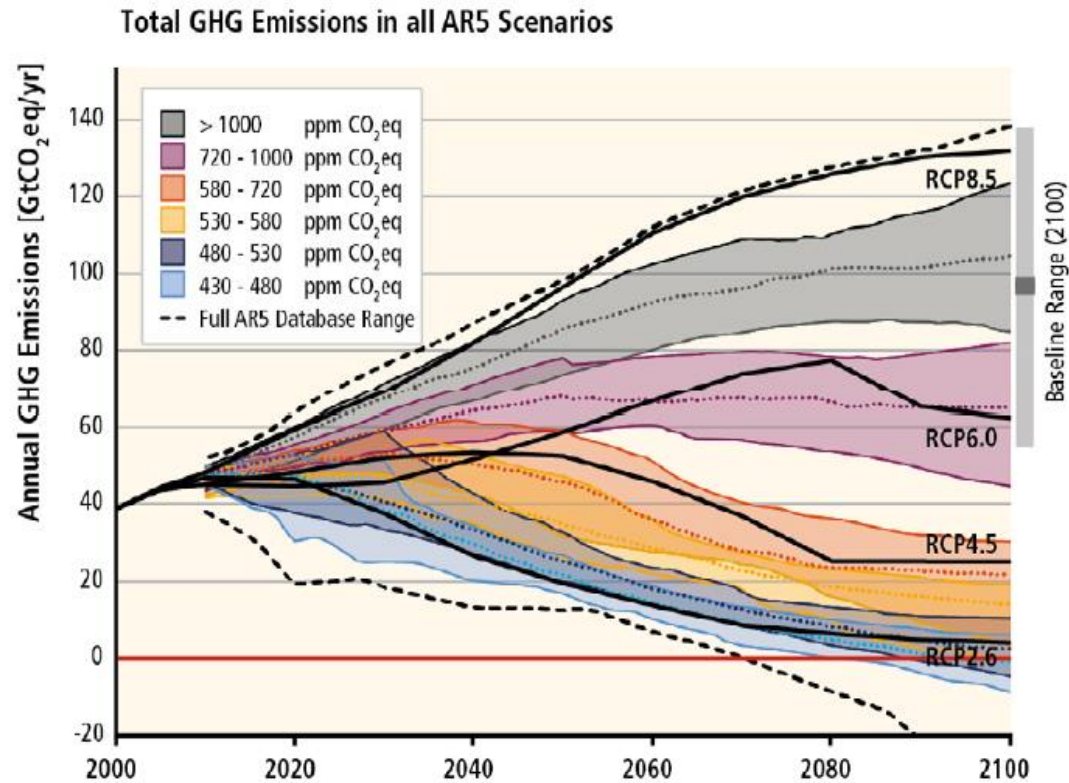
International Energy Workshop 2014
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Sabine Fuss (MCC),
Georg Kindermann (IIASA),
and many more...

Background

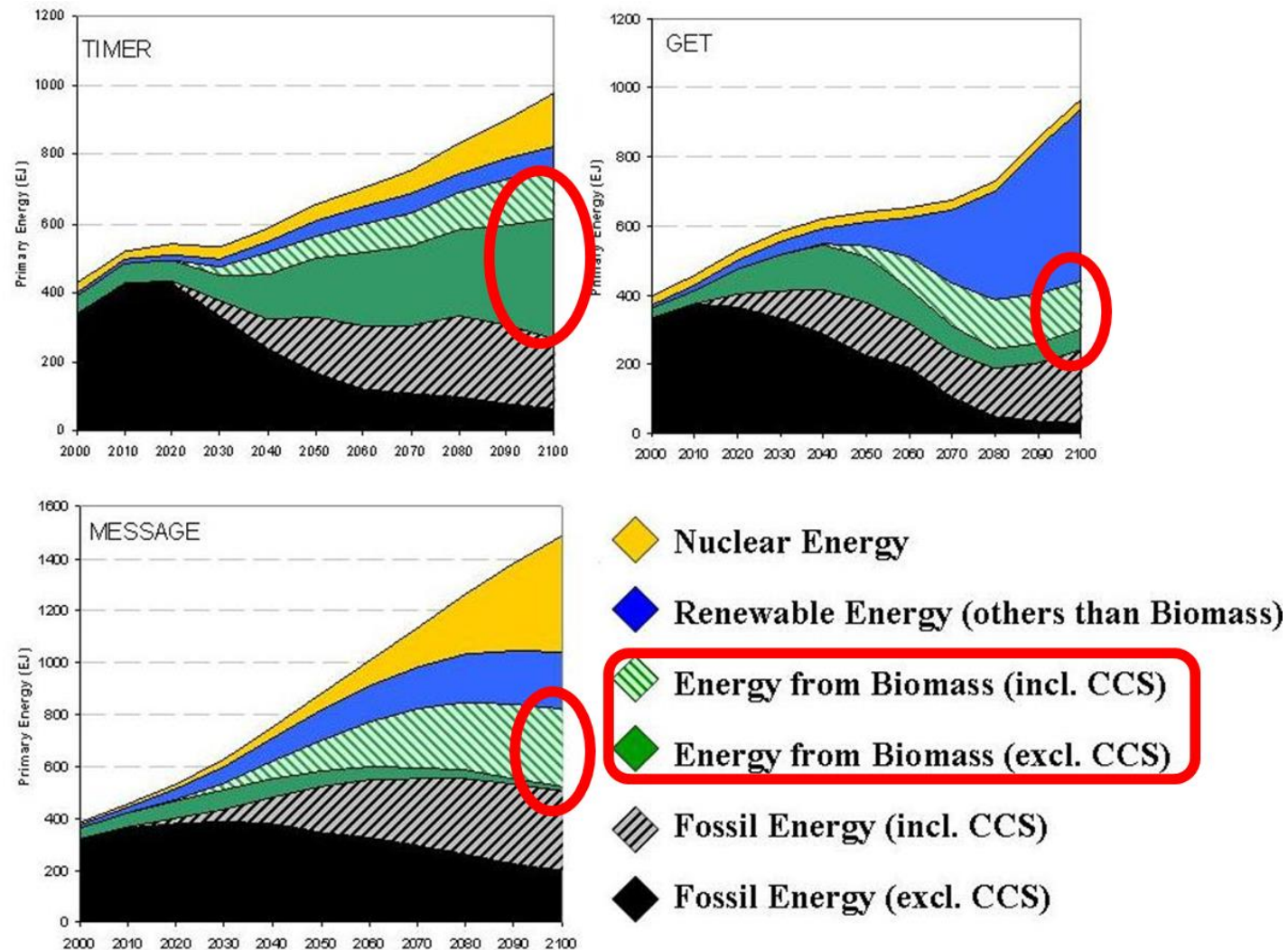
- Renewable energy (RE): EU climate change policy (2009/28/EC), nuclear phase-out
- Alpine Convention's Energy Protocol: Alpine region to make a long-term contribution to meeting Europe's energy needs (EC 2005, p. 37)
- Concern: ESS often compete with RE for productive sites \Rightarrow important tradeoffs to be analyzed to maintain ES functions and services under increasing RE demand and other pressures.
- Approach: use spatial optimization model to determine cost-optimal location of bioenergy plants under varying sustainability criteria (at different scales)
- Valuation concept: Analysis does not intend to assign monetary value to biodiversity \Rightarrow novel concept.
- Contributions:
 - Detailed spatial analysis of bioenergy solutions and tradeoffs in in multifunctional landscapes
 - Quantification and visualization of ecological-economic tradeoffs without making assumptions on weights and preferences and judgments about valuation
 - Aid decision-makers in forming strategies offering robustness across uncertainties

Background and Motivation (2°C target)



- RCP2.6 requires net negative emissions (i.e. BECCS) in the second half of the century.
- But also other RCPs contain NET deployment (though not resulting in net negative emissions)

Global Energy Portfolio - 2100



Approach

Bioenergy production VERSUS (?) Carbon Sequestration

ESS survey & identification

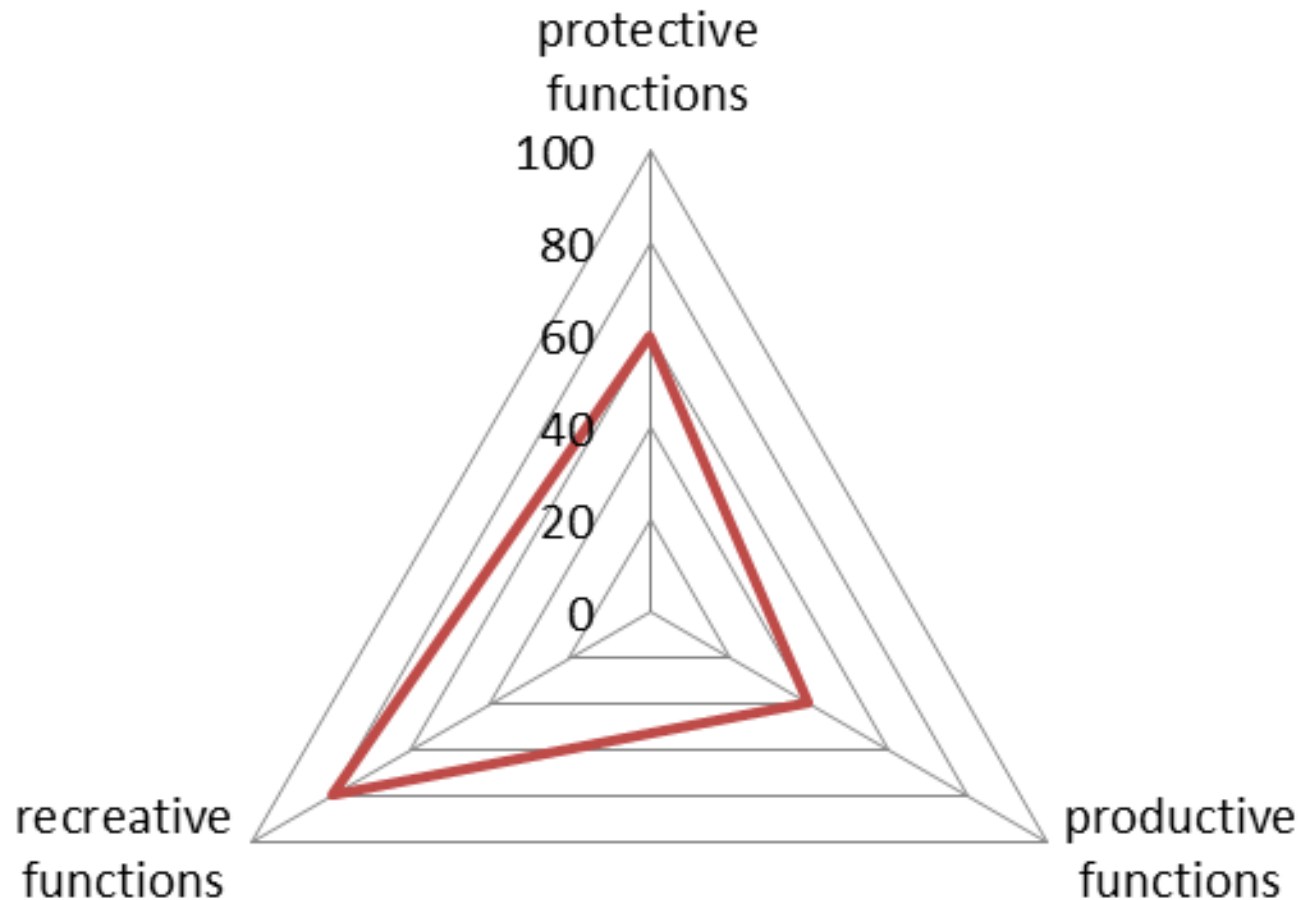
- Energy supply
- Bioenergy (CHP)
- Tourism
- Biodiversity
- Landscape
- Etc...



**Marginal Protection
Cost Curves (MPC)**

How does the public value the importance of Ecosystems Services (ES) in the European Forests?

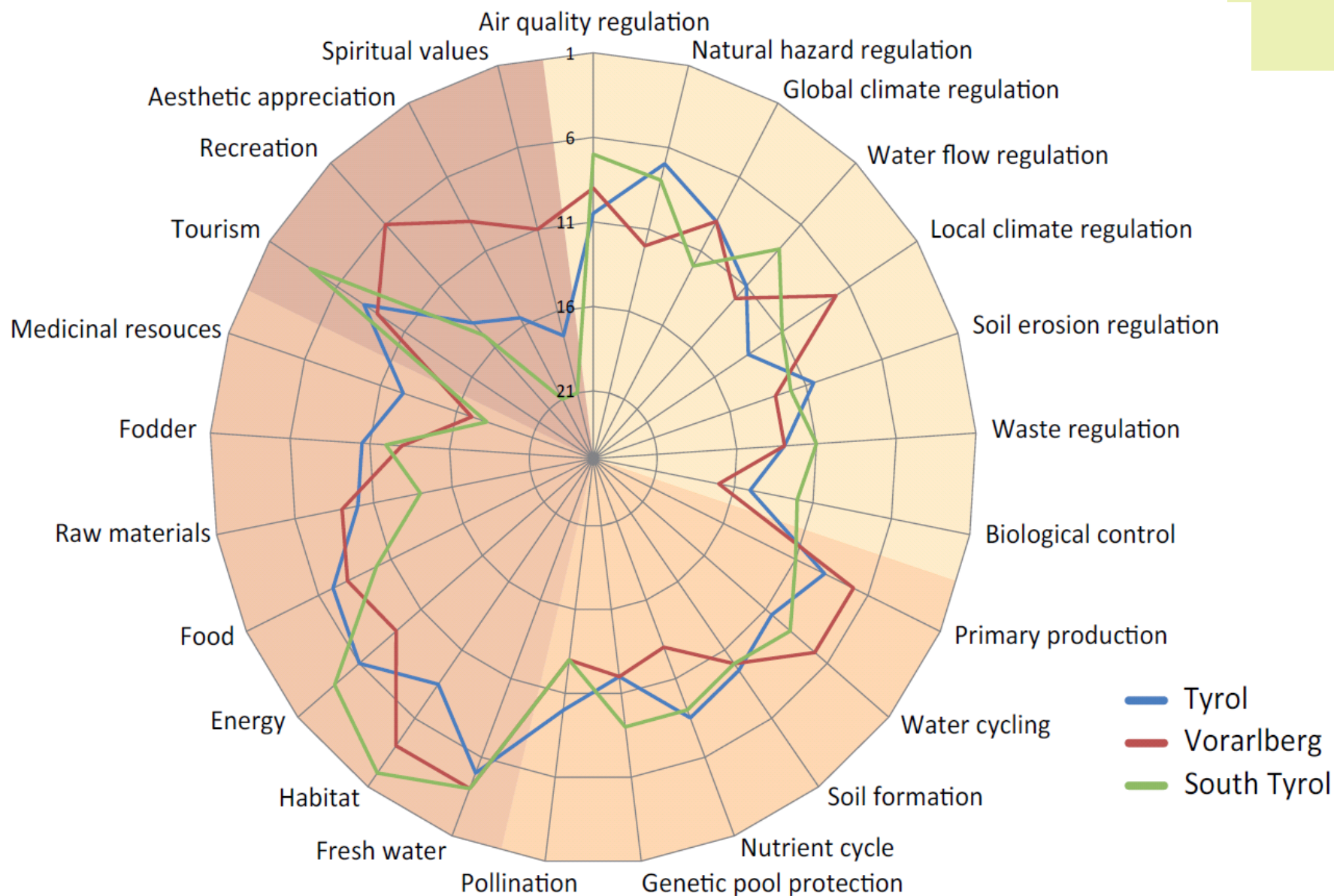
recharge  green



Modified after Rametsteiner and Kraxner (2004)

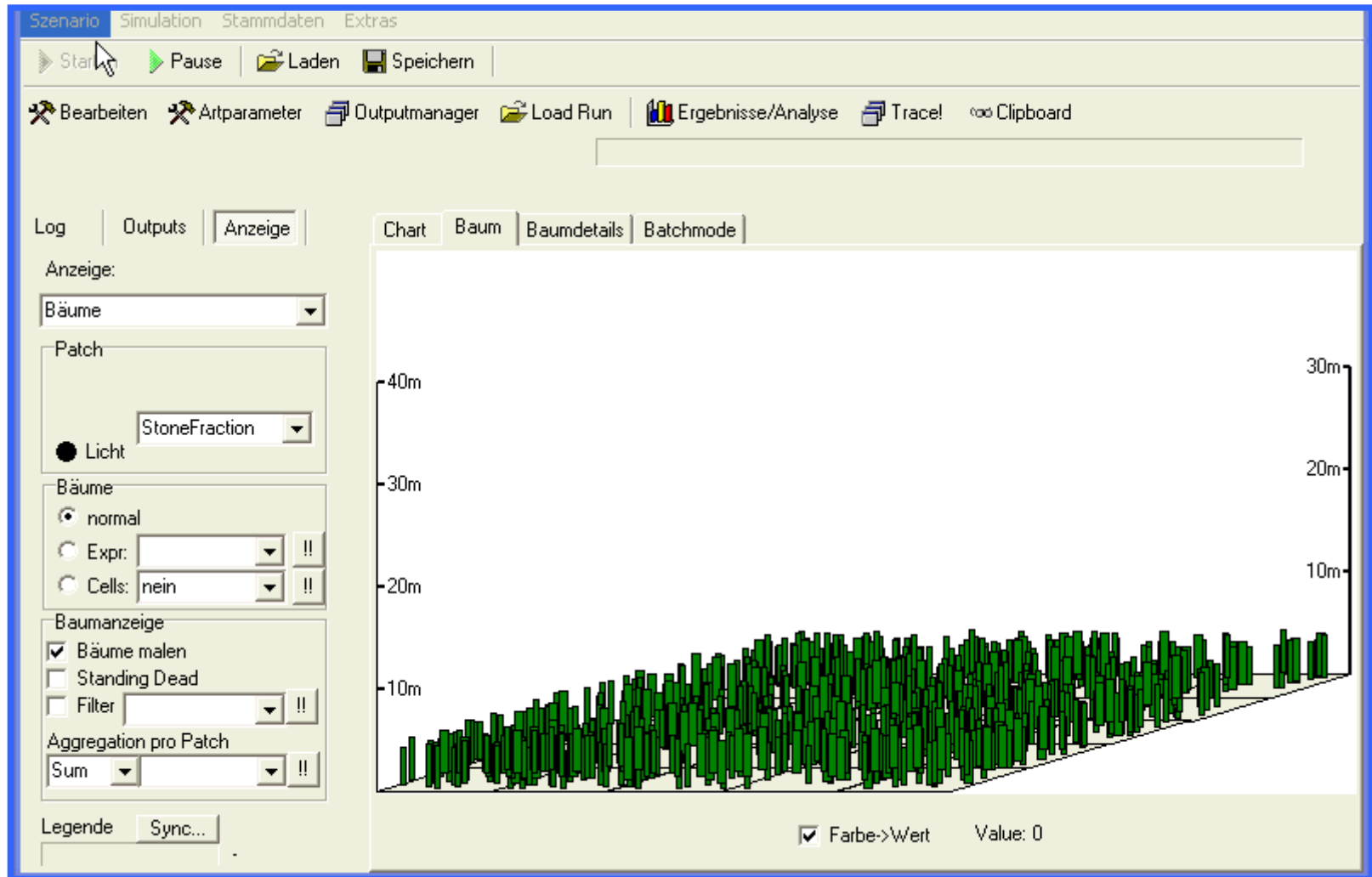
Experts ranking ES in the Alps

recharge  green

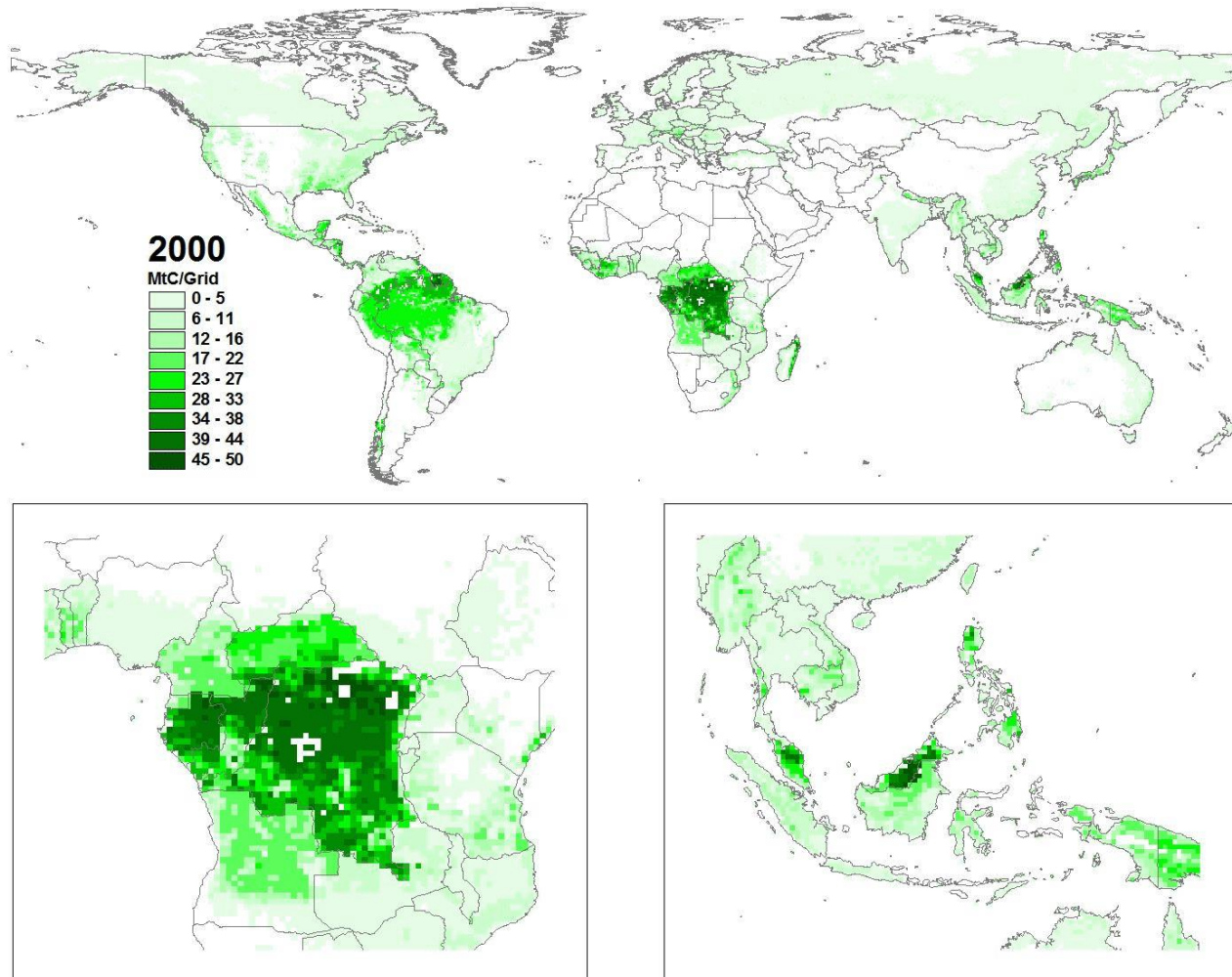


Haida et al., 2013 (UIBK)

Bottom-up Forest Modeling



Forest Area Development A2r (2000 – 2035)

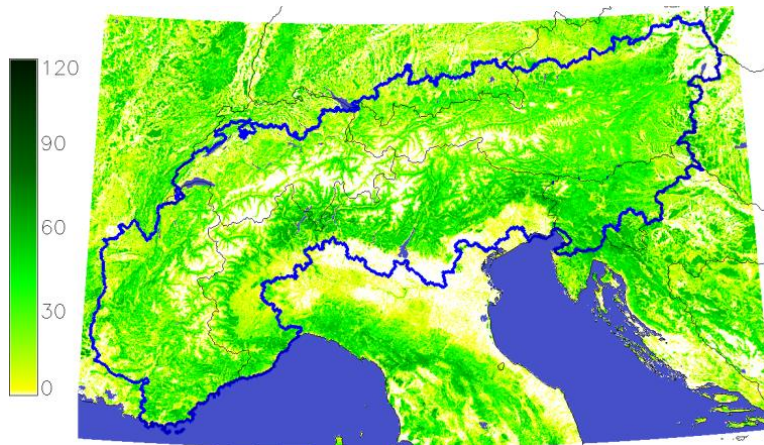


Scenario description

Forest Management

(S1)
Bioenergy

Carbon stock (t_c/ha)



Carbon increment ($t_c/ha/a$)



(S2)
C-Sequestration



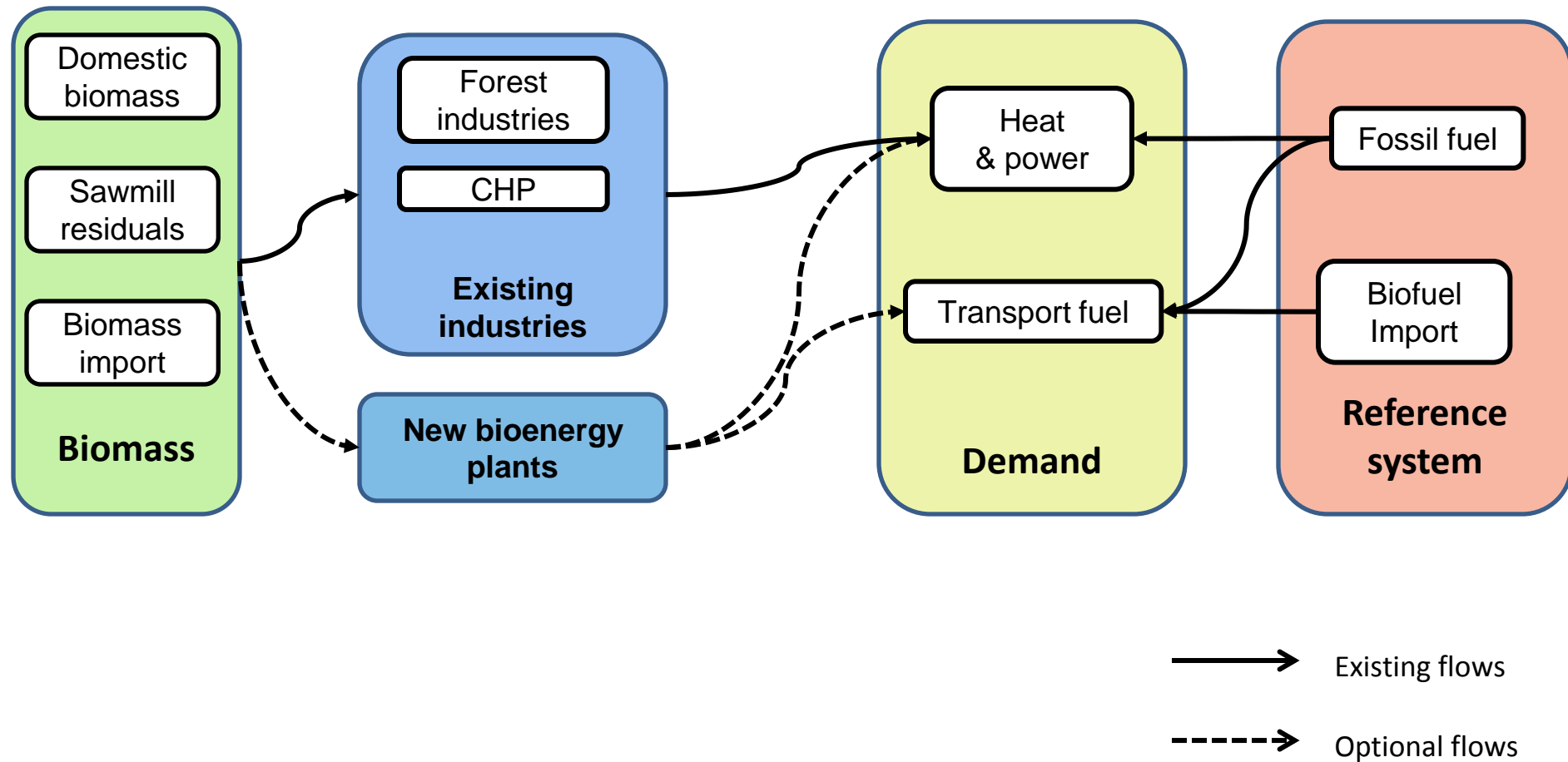
BeWhere Model

- Use the **BeWhere** Model* to optimize location and size of bioenergy units given the supply chain.
 - feedstock supply (incl. harvesting, transportation, etc.)
 - transportation routes/costs
 - trading possibilities
 - competition with other industries for feedstock
 - distribution networks
 - proximity to demand centers
- Mixed integer linear programming, economies of scale
- Geographically explicit on a 0.5 degree grid

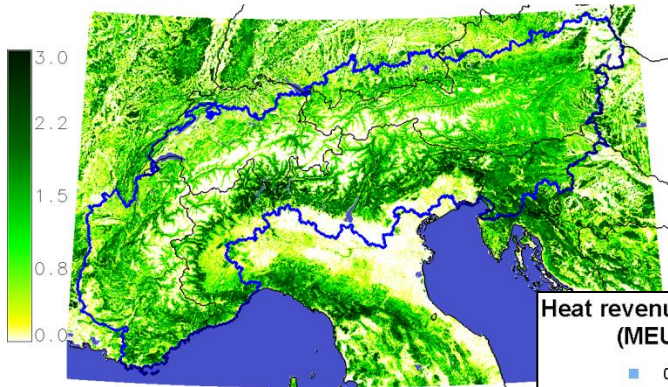


* e.g.: Leduc S, Schmid E, Obersteiner M, Riahi K (2009)
Methanol production by gasification using a geographically explicit model.
Biomass and Bioenergy, 33(5):745-751

BeWhere Model – Forest

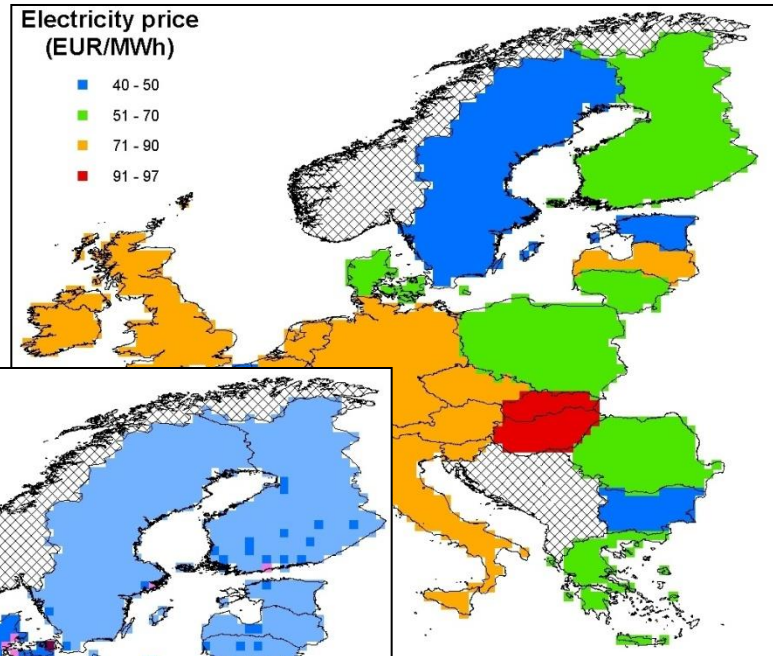


Input data

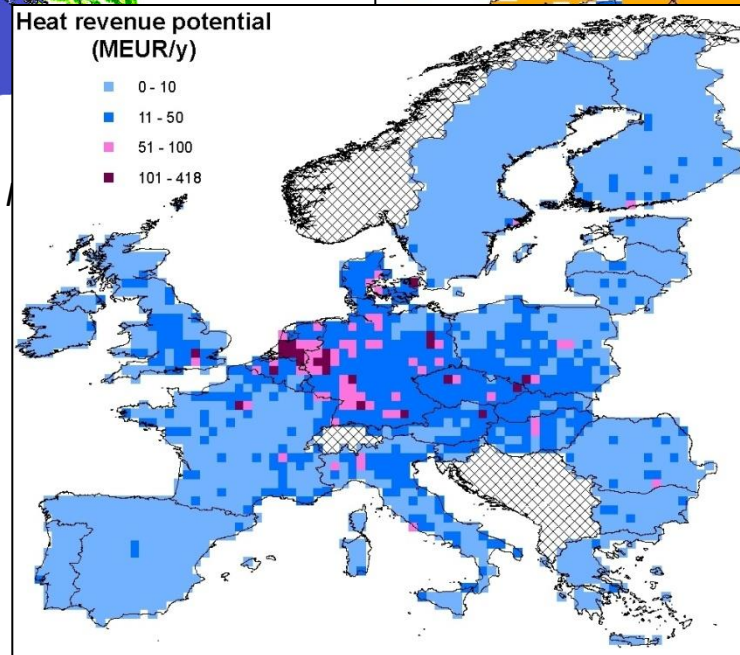


Forest residuals

Source: results from G4M model, 1

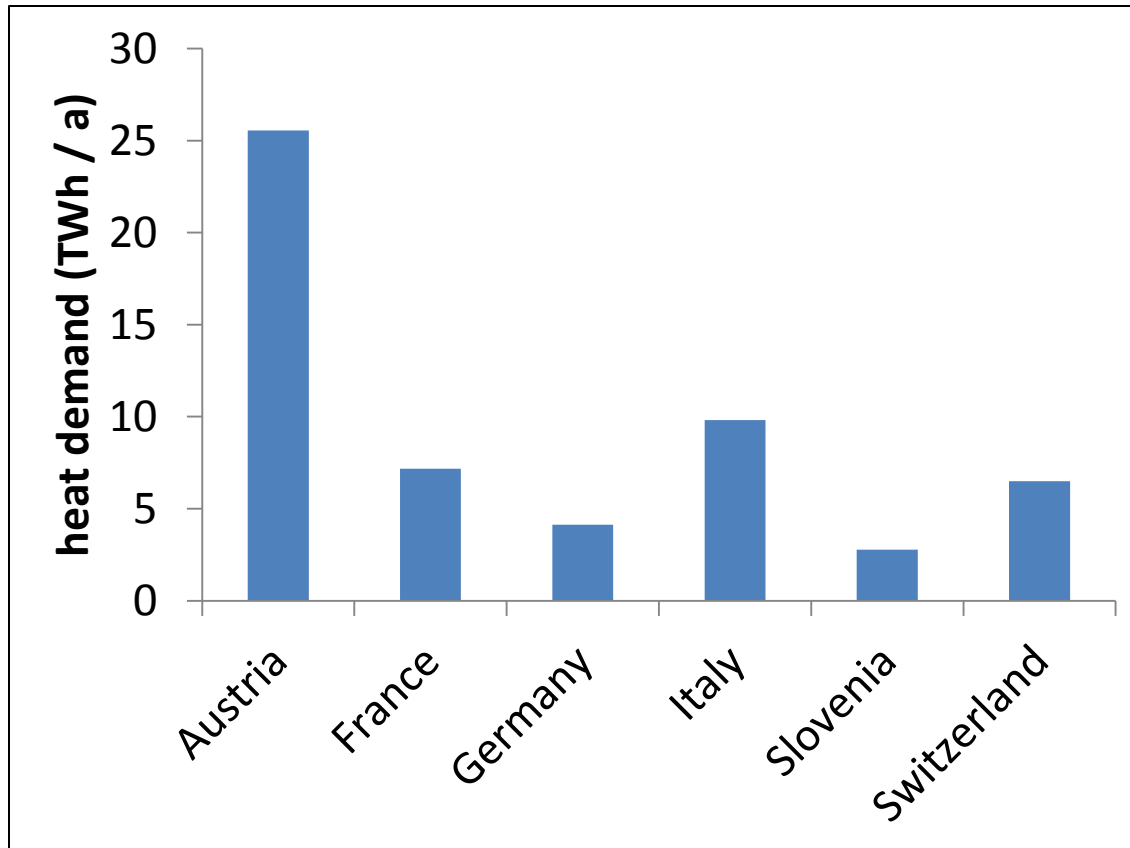


Source: Eurostat, 2010



Source: Werner, 2006

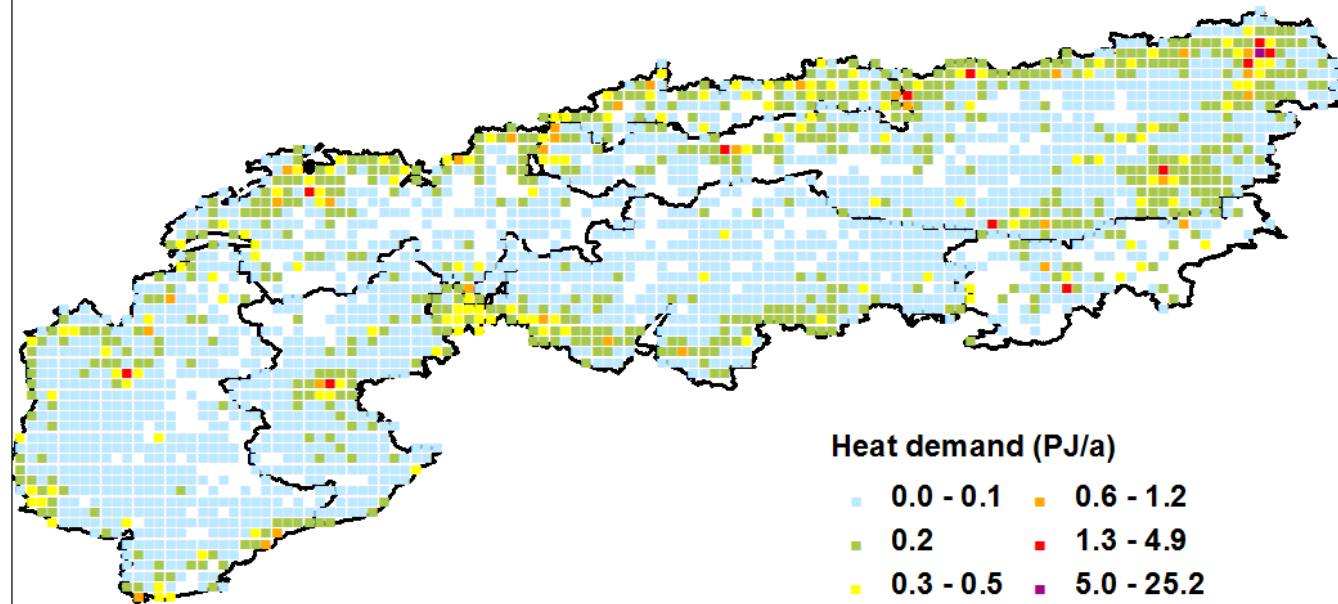
Heat demand in the Alpine region



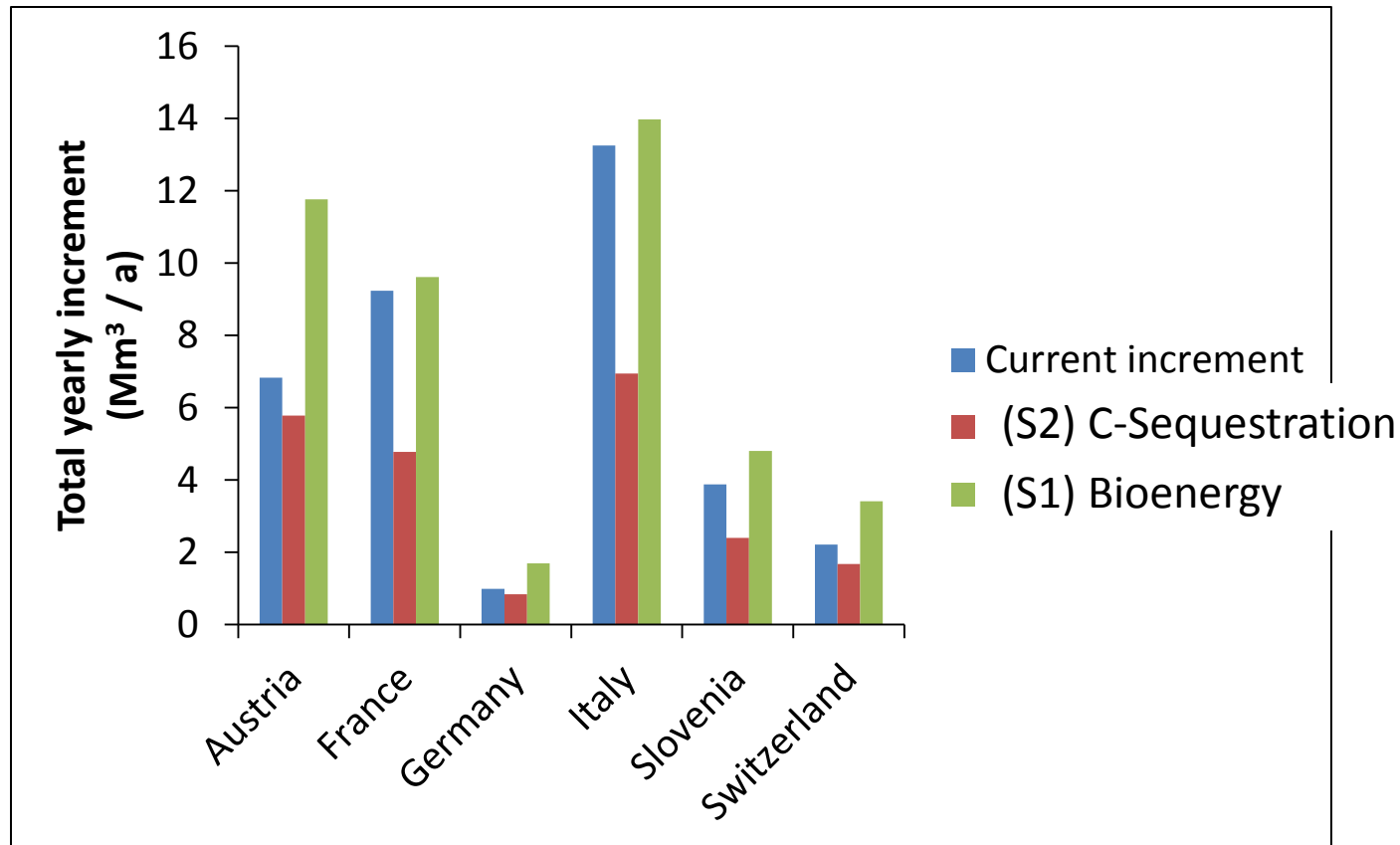
- 3 seasons for the heat over the year (high, medium, low)
- Heat can be delivered over a distance of max 20 km
- Power send to the grid

Source: Eurostat, Werner 2006, Berndes et al 2010.

Heat demand over the Alps in BeWhere



Yearly biomass increment in the Alps (G4M)



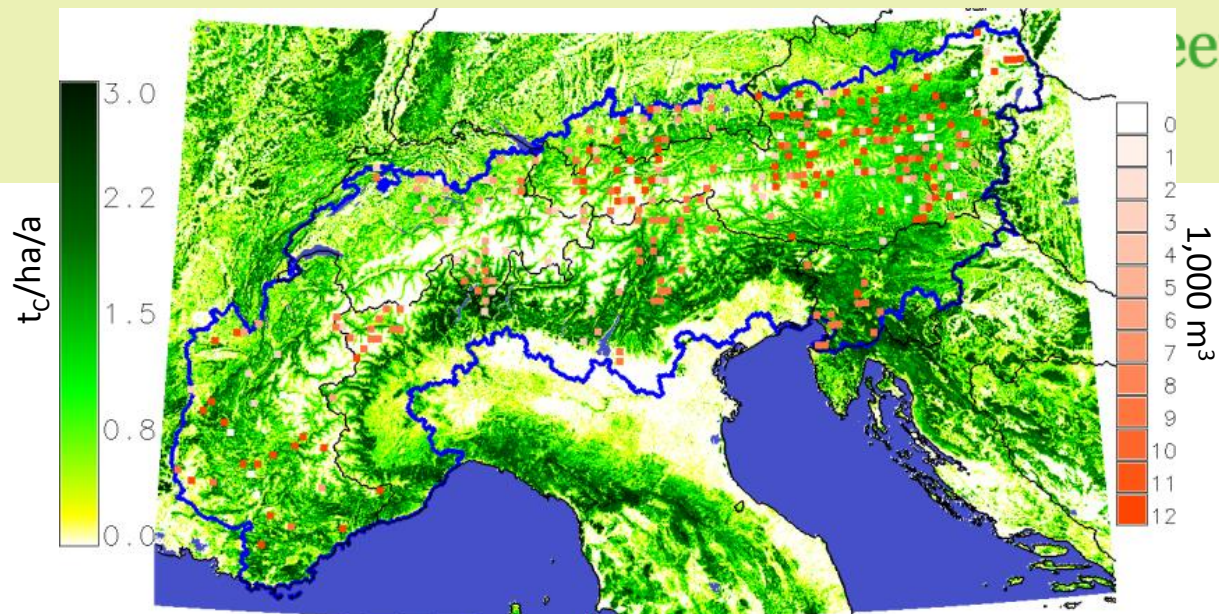
Source: G4M (www.iiasa.ac.at/g4m)

Optimization Assumptions and Conditions

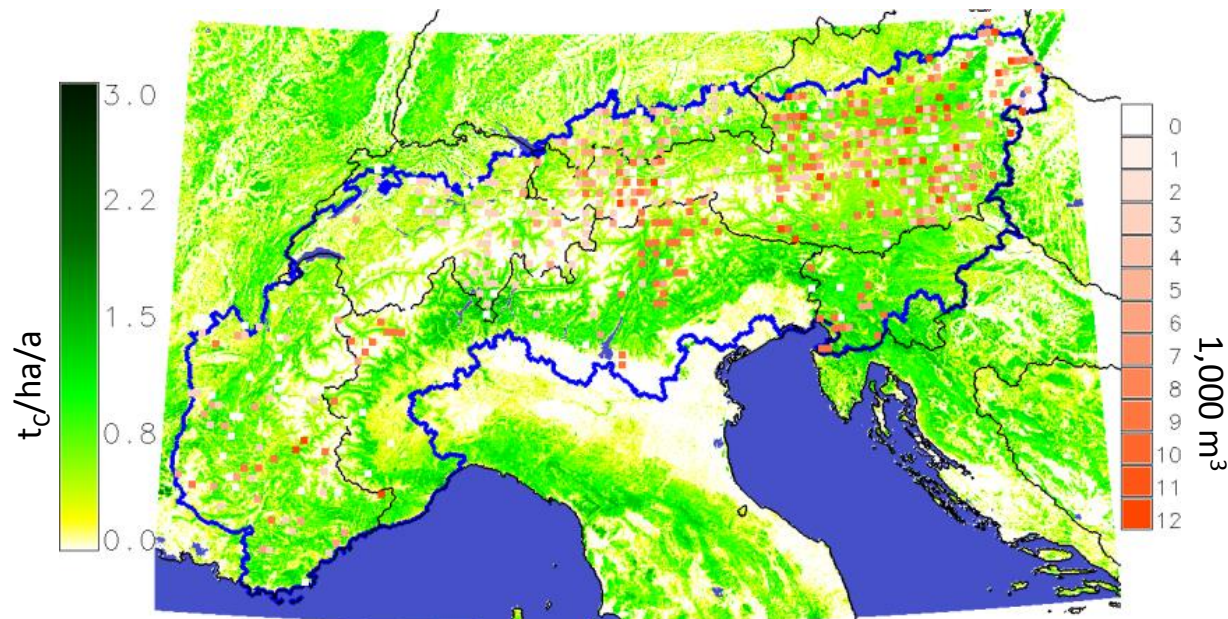
- Target: 5% of heat from bio-energy per country or region of the country belonging to the Alps.
- Only 50% of increment used for heat/electricity production
- Rest dedicated to existing industries
- Truck and train transport possible
(No transport by boat assumed)
No trades between the countries.
Trades can be set on or off on demand.
- Heat distributed to district heating network
- Power, sent to the grid at the spot
(grid network required for future)

First Results Harvesting Locations and Intensities

(S1)
Bioenergy FM



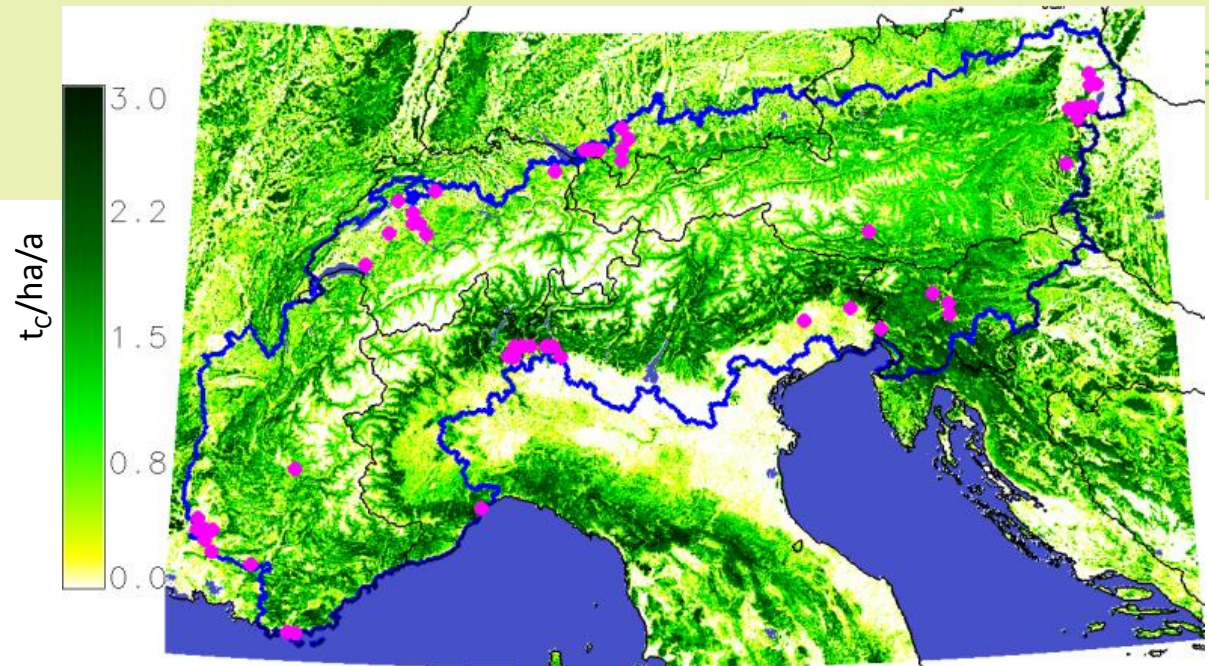
(S2)
C-Sequestration FM



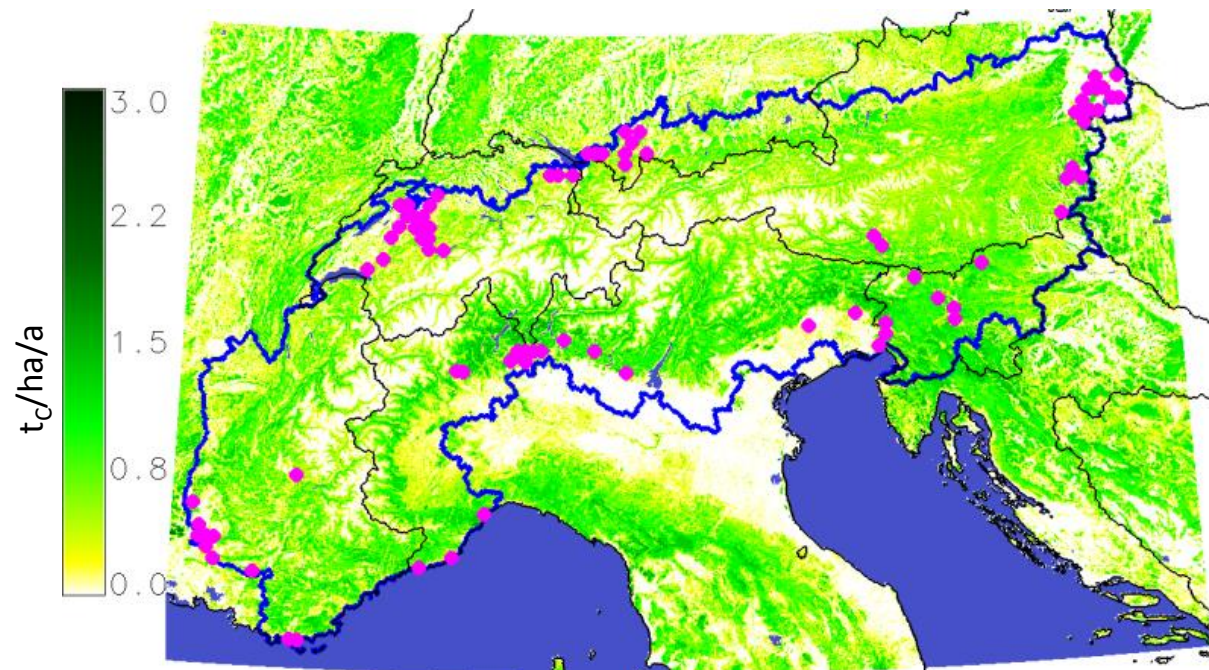
First Results Powerplants

en

(S1)
Bioenergy FM



(S2)
C-Sequestration FM



(Sub-) Scenarios

Scenarios	Biomass available	Fossil fuel factor increase	Trades
1..60	5% → 100%	0.75 → 100	Yes / No

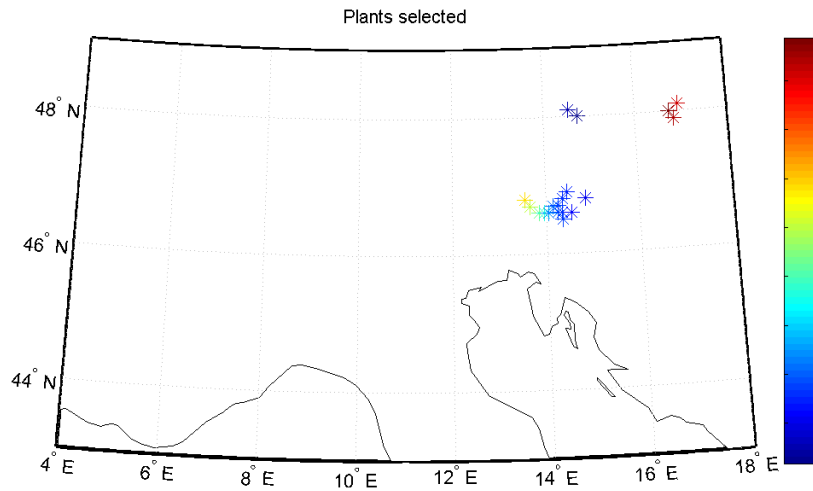
Results:

1. Biomass collected
2. Energy cost
3. Plant location and capacity

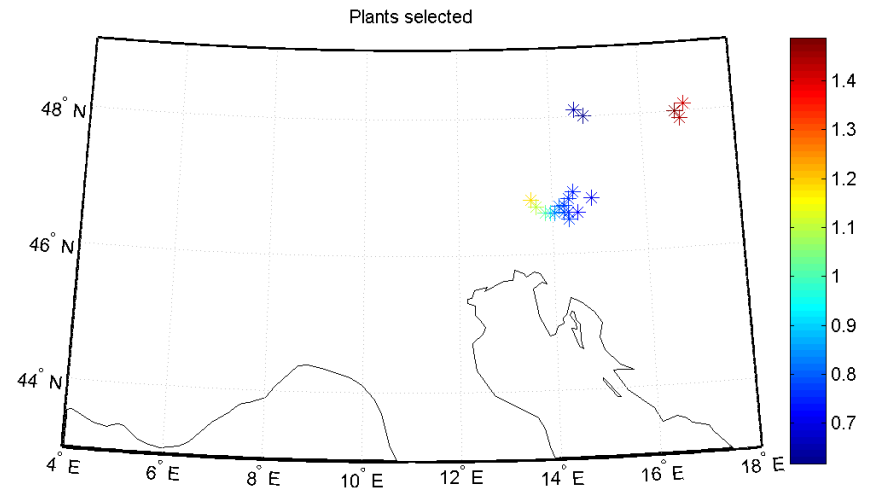
Fossil fuel factor: 0.75

recharge  green

With trades

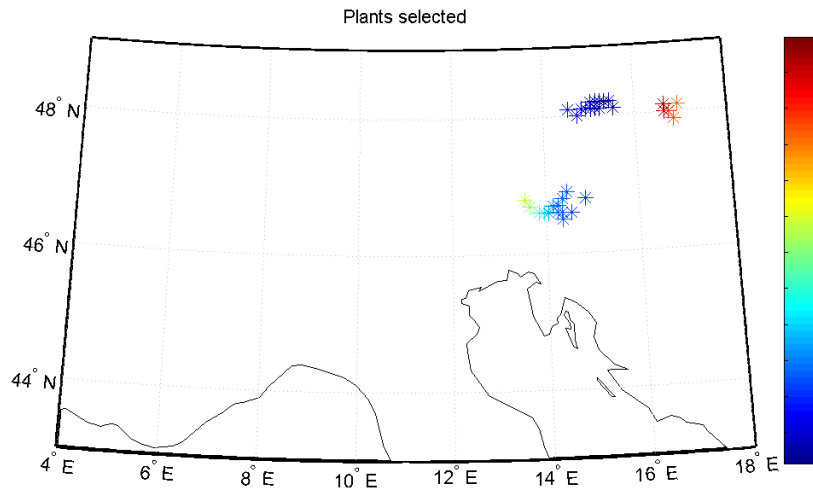


No trades

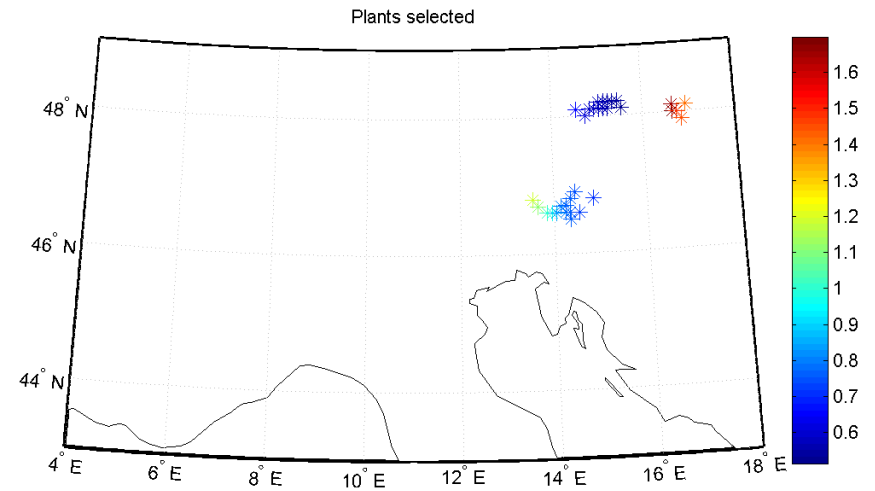


Fossil fuel factor: 1

With trades

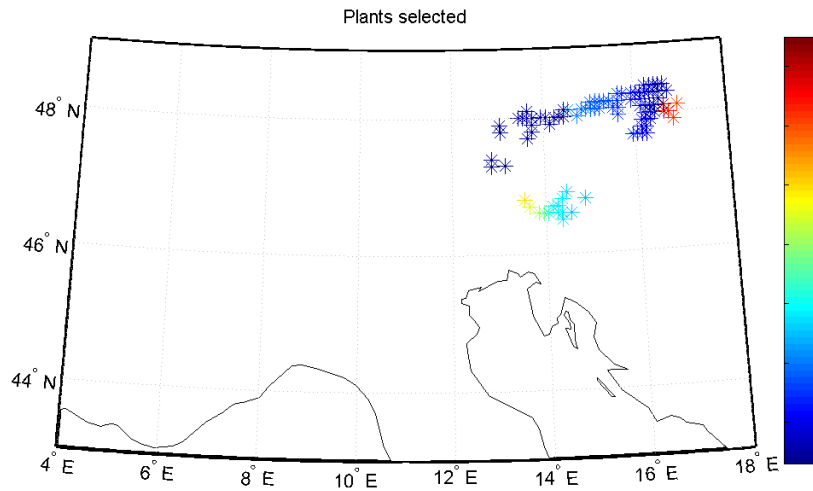


No trades

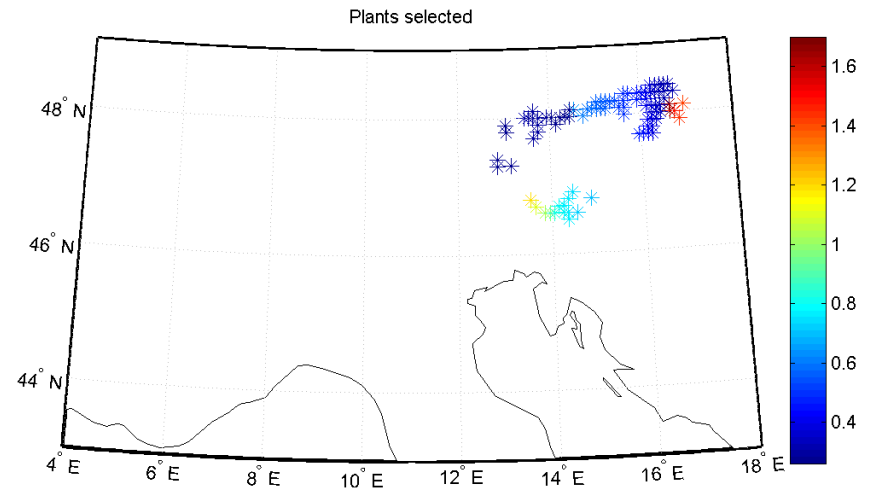


Fossil fuel factor: 2.5

With trades

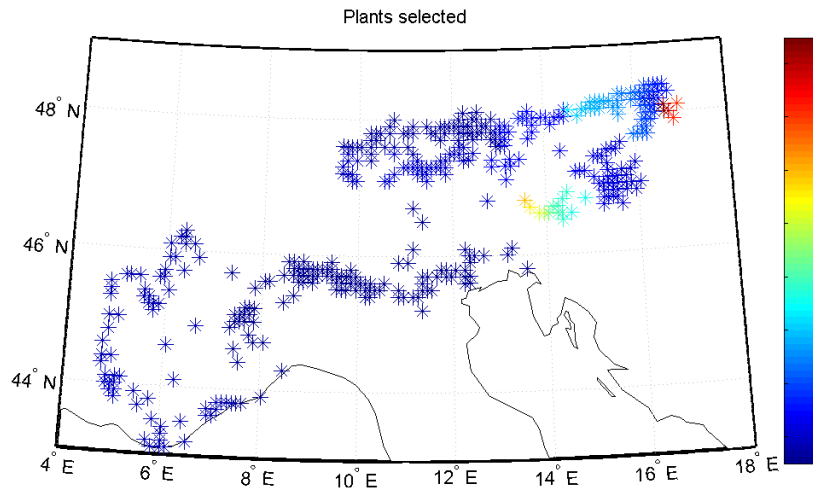


No trades

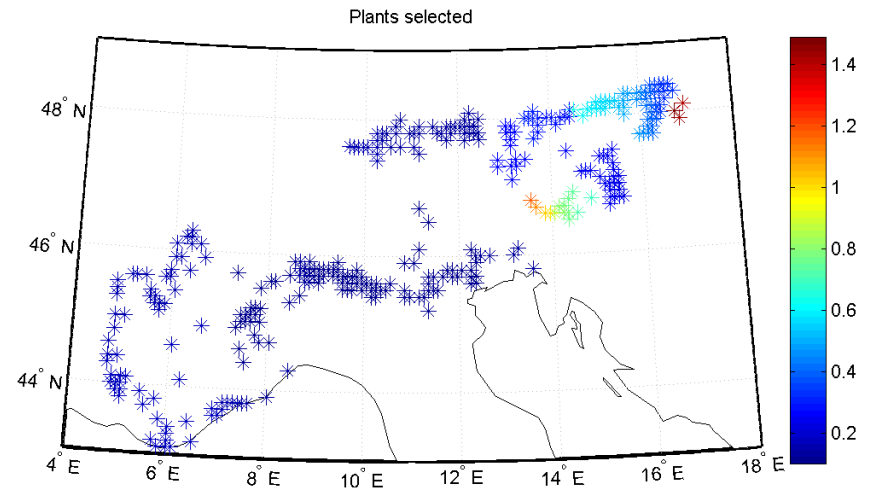


Fossil fuel factor: 10

With trades

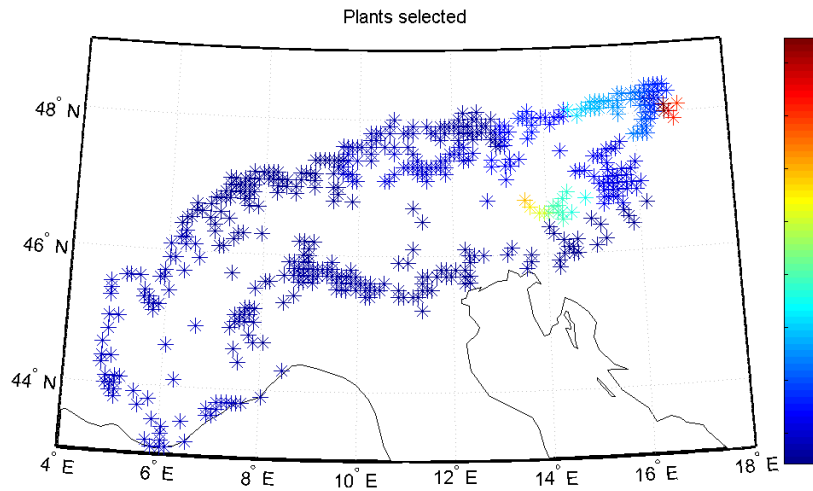


No trades

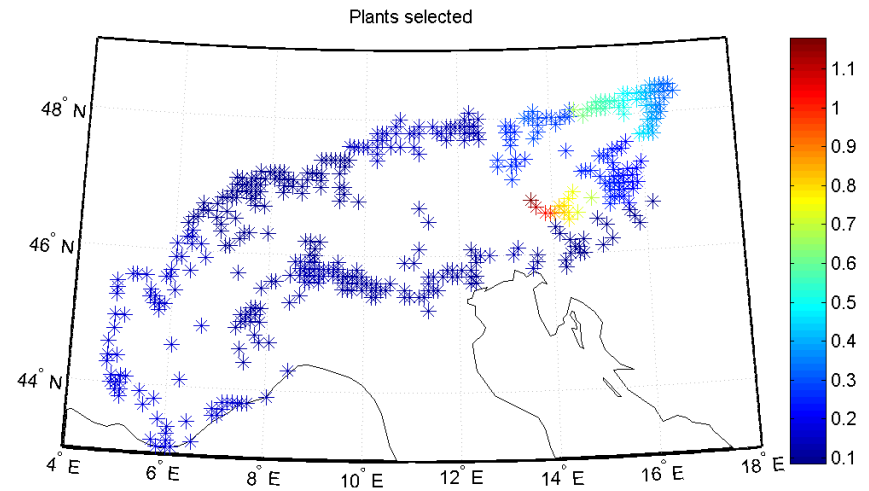


Fossil fuel factor: 100

With trades

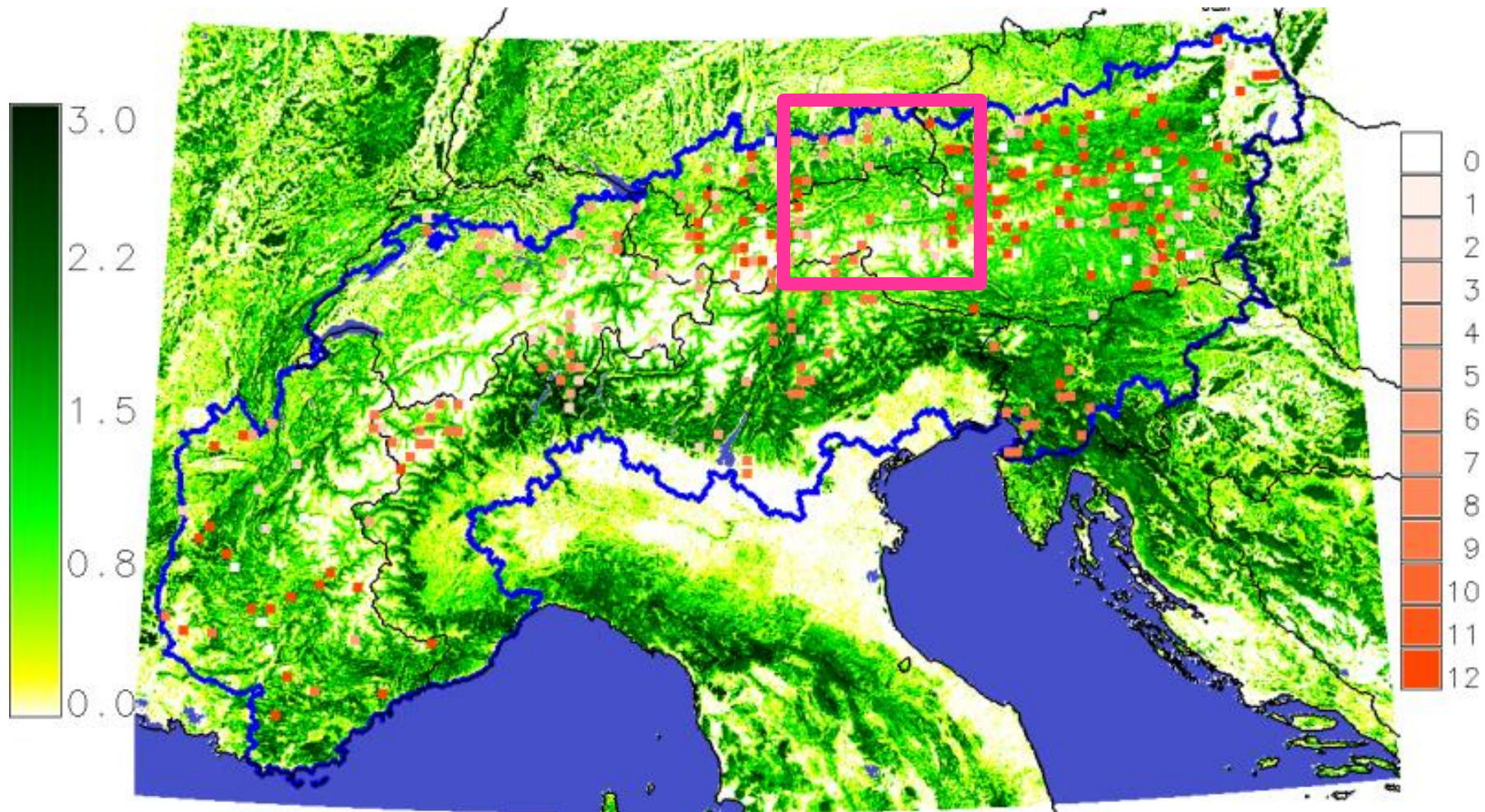


No trades



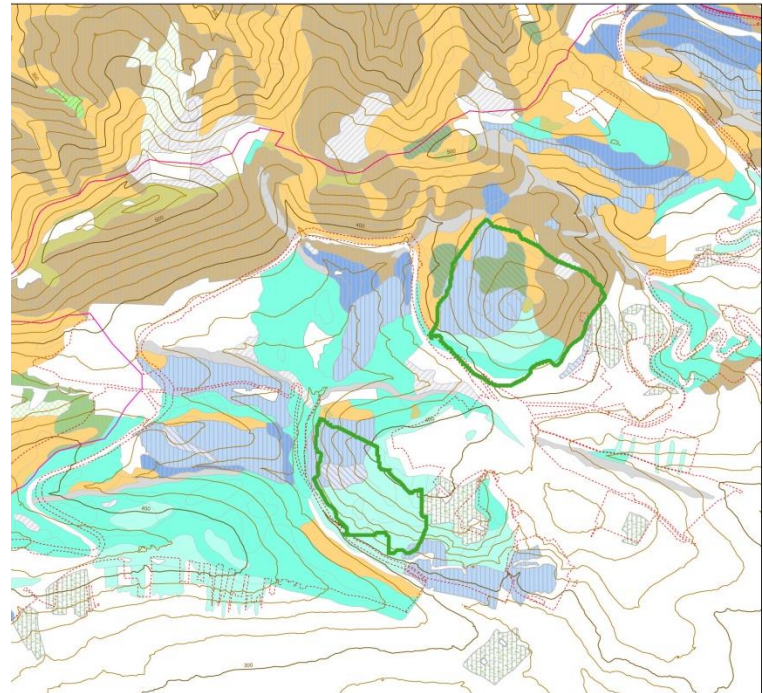
Intensification Effect

recharge  green



Intensification Effect for improved planning

recharge  green



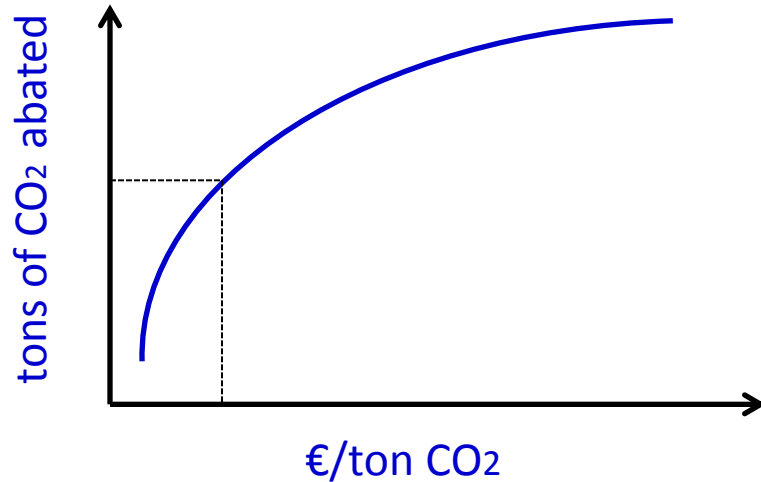
- Where do I manage more intensively, while I take management and production pressure off other areas that can consequently serve other Ecosystem Services or can be protected...?

Economic Assessment

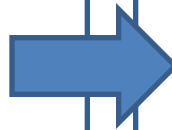
Marginal Protection Cost Concept

- ESS values difficult to quantify, need value judgements, surveys imperfect, no agreement on which ESS will be modeled, no consistent data sets, etc
- Suggested solution: Compute marginal protection costs much like the concept of marginal abatement costs:
 - circumvents the problems of assigning monetary value to ESS
 - enables us to say how much preservation will cost in terms of more expensive RE
 - leaving value judgements to preference of the user

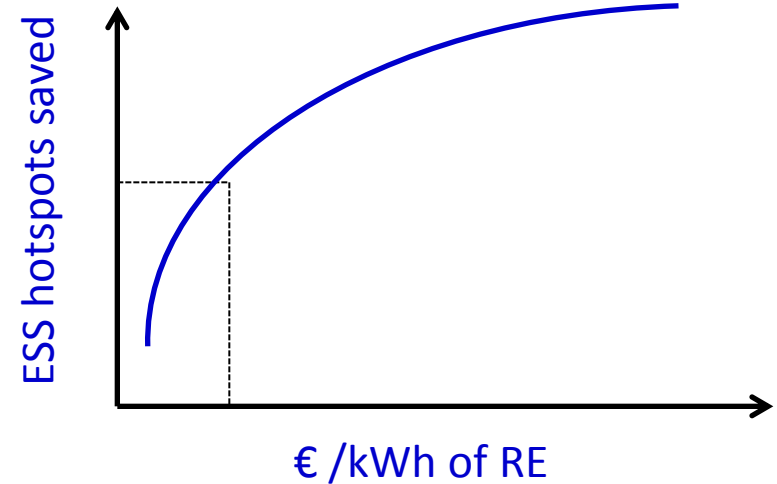
MAC



Each additional ton of CO₂ abated will increase the cost of abating the next one, as low-cost opportunities are exploited and more expensive abatement options have to be employed.



MPC

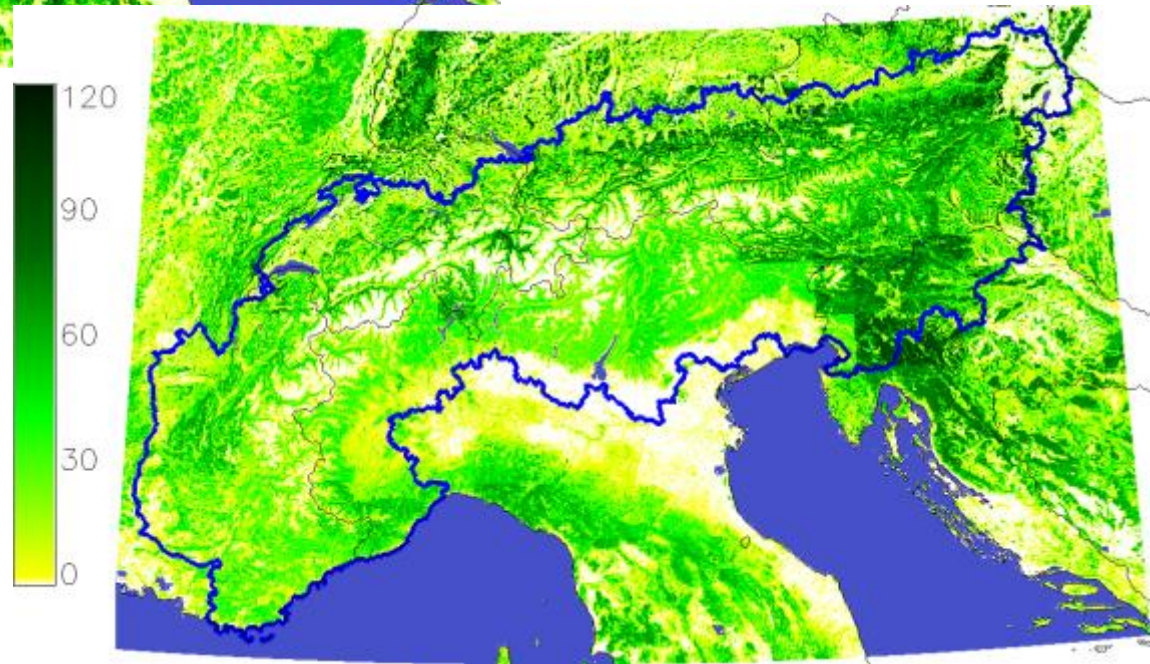


Each additional area with important ESS excluded from RE deployment/protected will increase the cost of delivering another kWh of RE, as we have to resort to less productive areas.

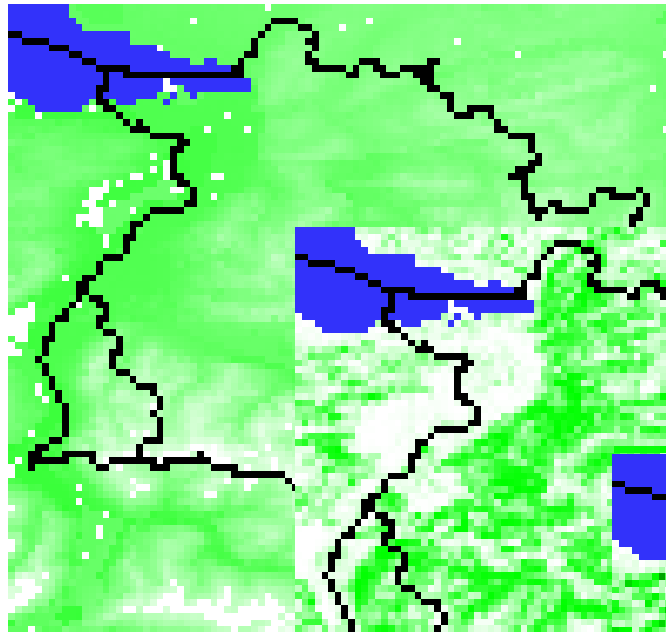


Biomass: current increment

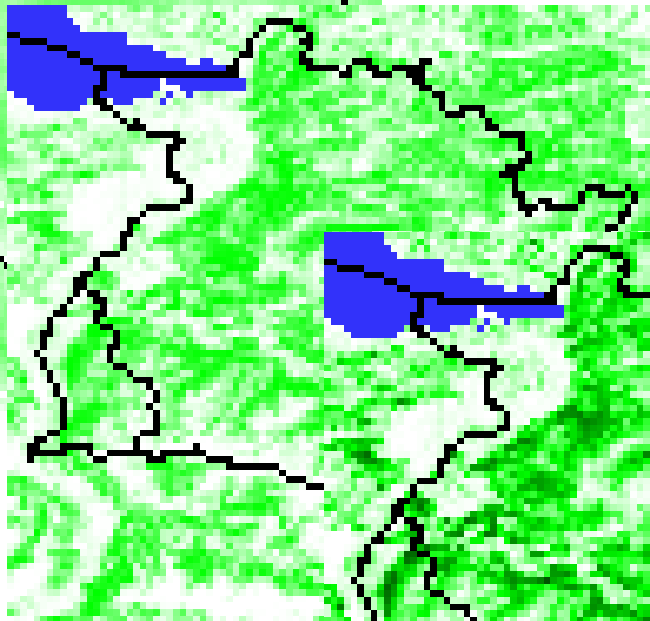
Biomass: current stock



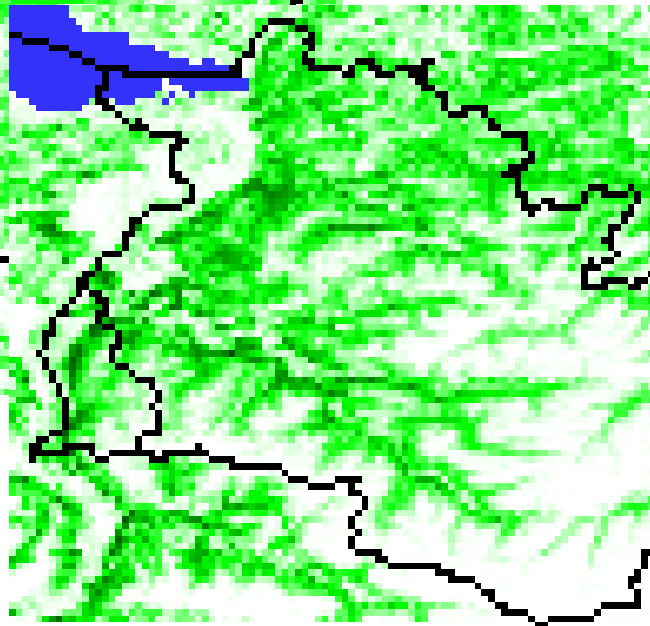
Regional zoom: Vorarlberg's biomass



Potential Forest
Increment



Current Forest
Cover Map



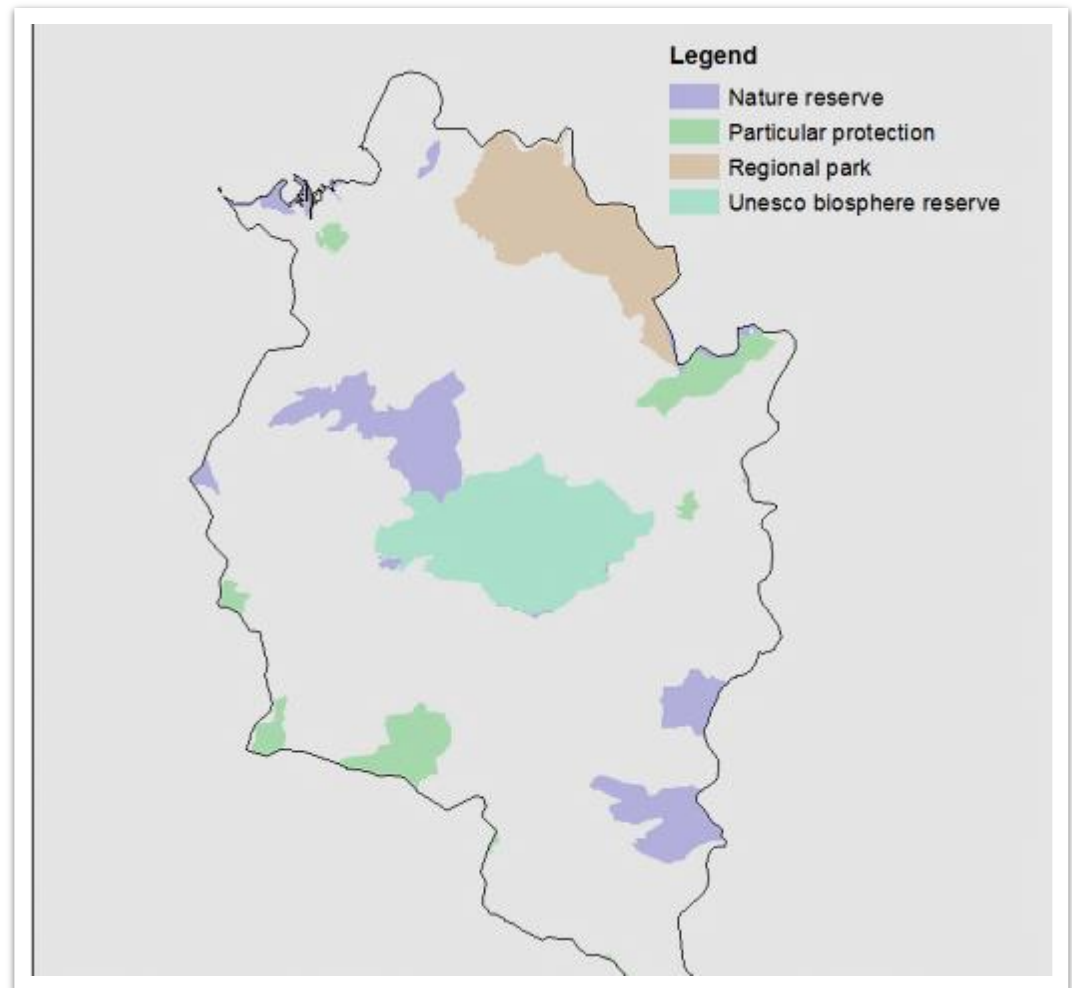
Potential
Increment in
Current Forest



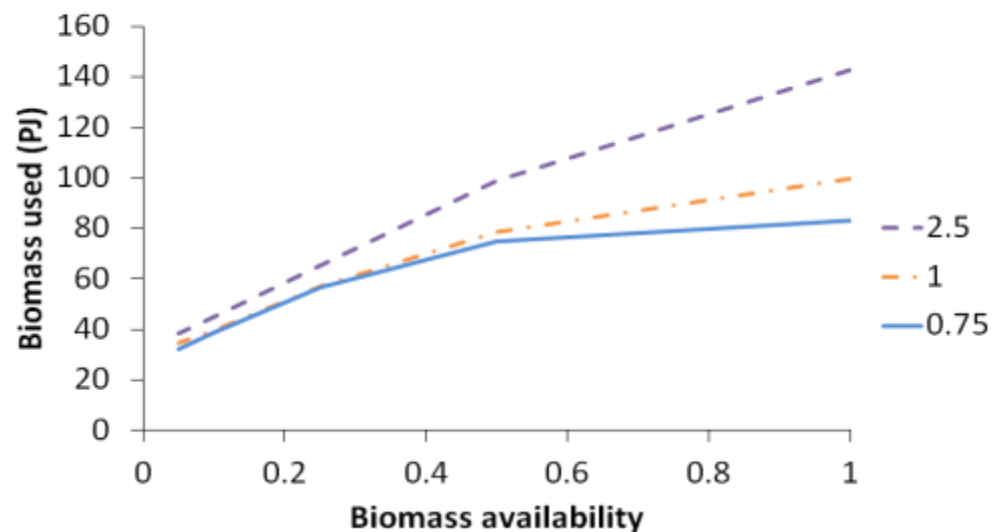
G4M

Vorarlberg's protected areas

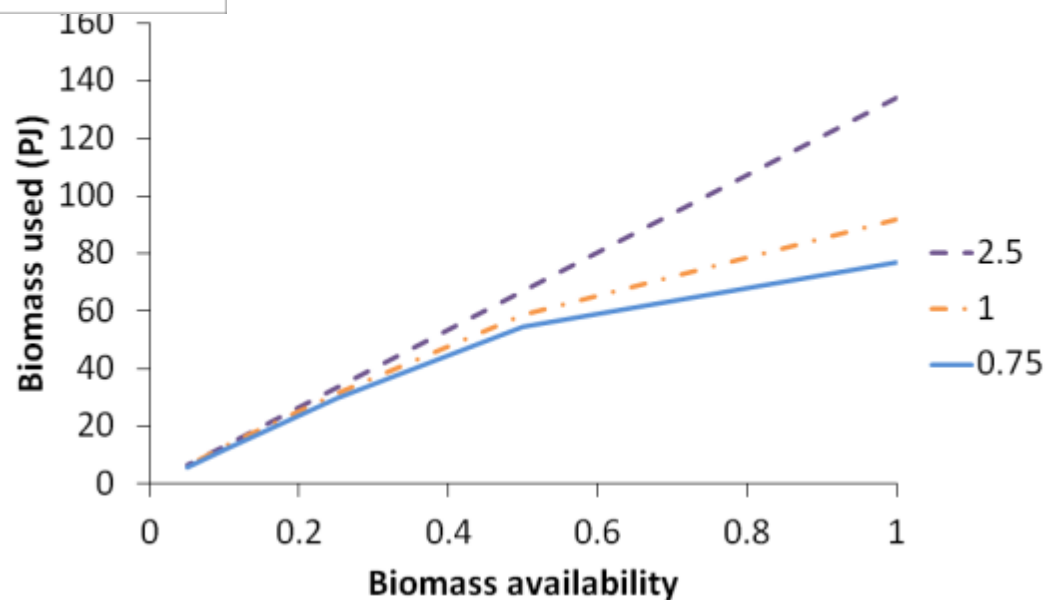
- The sum of all protected/biodiverse areas still amounts to a substantial part of Vorarlberg's land area.
- But: reserves are often where biomass productivity is not the highest in the first place.



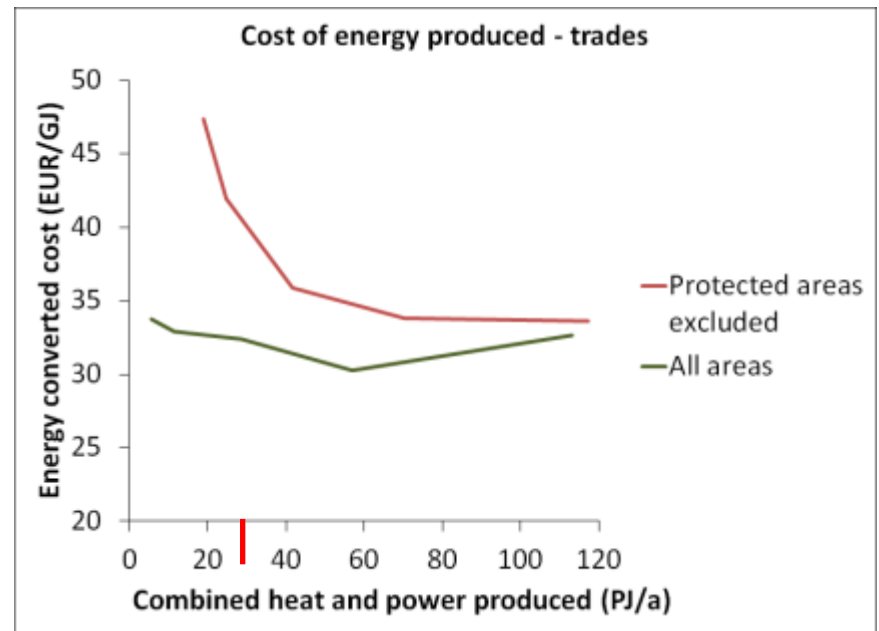
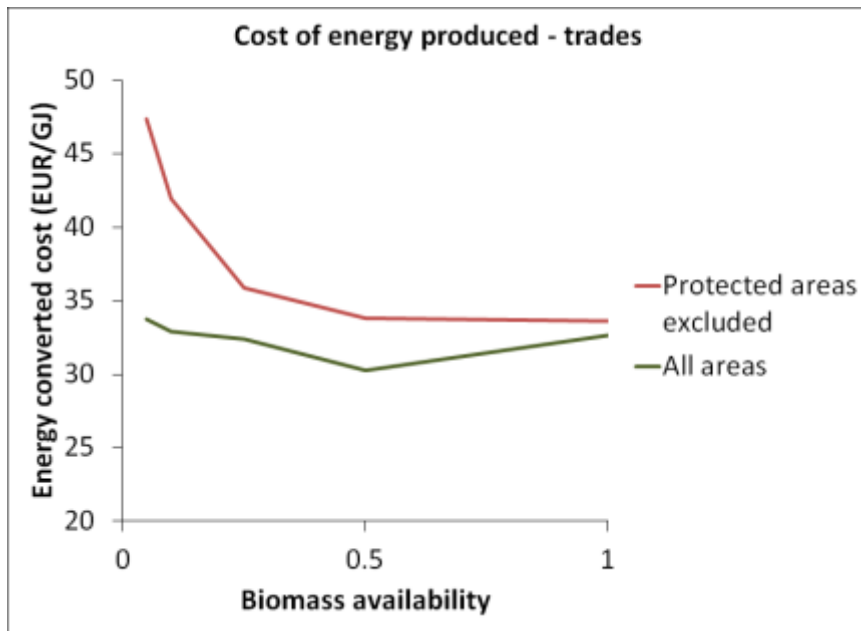
**Biomass used for Energy purposes
vs availability - With trade
Include protected areas**



**Biomass used for Energy purposes
vs availability - With trade
Exclude protected areas**

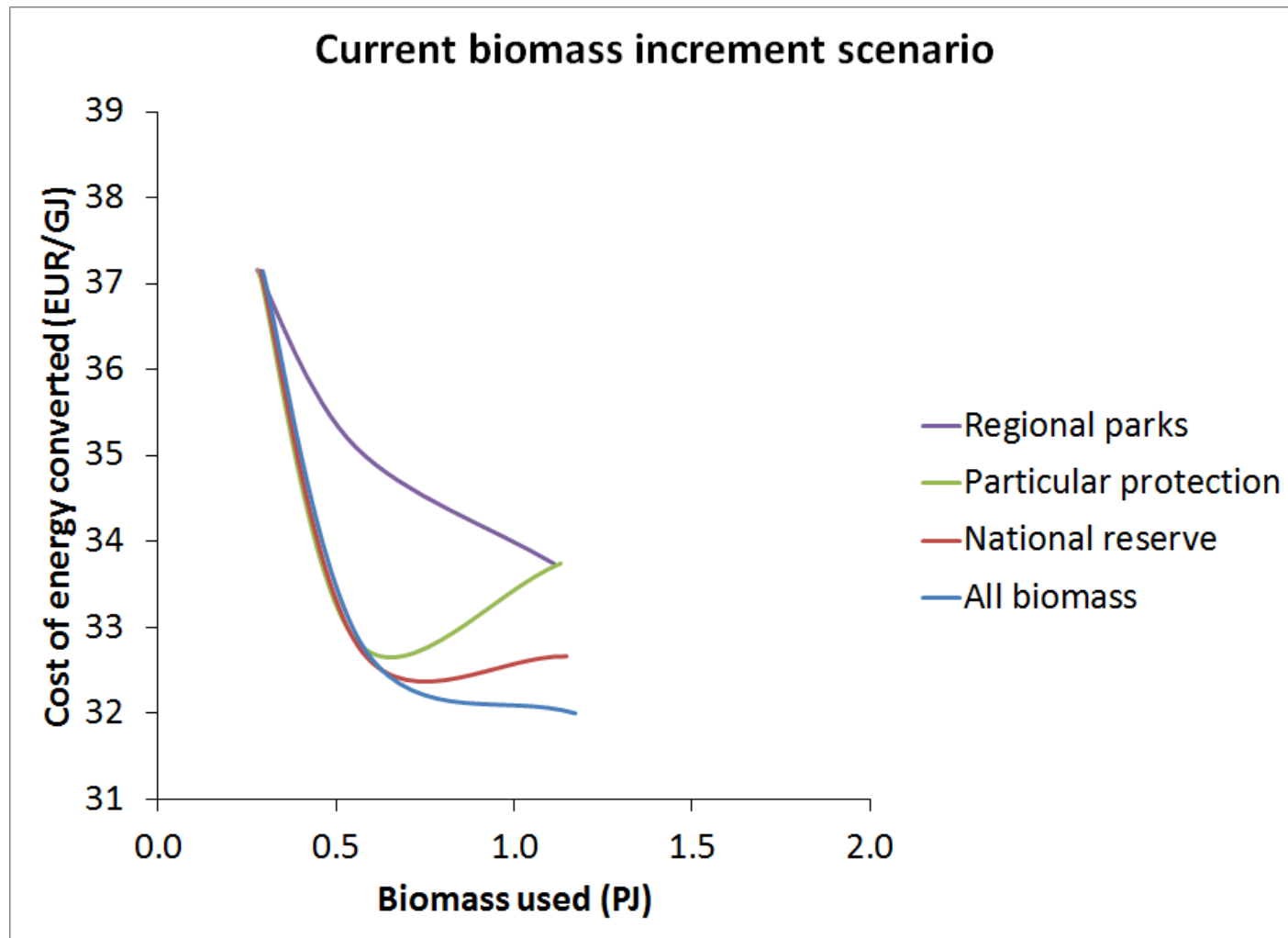


Bioenergy costs in the Alps with/out protection



Total Austrian 2012 final energy demand was 1100 PJ
For Vorarlberg 35PJ |

Marginal protection cost in Vorarlberg



Conclusions for MPC

- Alps:
 - If 20% of the biomass increment can be used for bioenergy, then approx. 20 PJ are used when all areas are protected, while up to 50 PJ are used if no areas are protected underlining the importance of analyzing the tradeoff between protection and bioenergy provision.
 - Low levels of bioenergy will be more expensive to generate if all biodiverse areas are protected, but the difference is marginal and will shrink as production expands and economies to scale are achieved.
- Vorarlberg:
 - Costs increase, as we move into areas where bioenergy generation is more expensive due to restrictions on location and scale of plants.
 - Marginal protection costs relatively low, especially for low production levels and not excluding regional parks.
 - Importance of zooming into regions, rather than drawing quick conclusions on aggregate estimates.

Contact & Acknowledgment

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