Mercator Research Institute on
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IIASA

Spatial modeling of ecological-economic tradeoffs: renewable energy production & biodiversity conservation in the Alps

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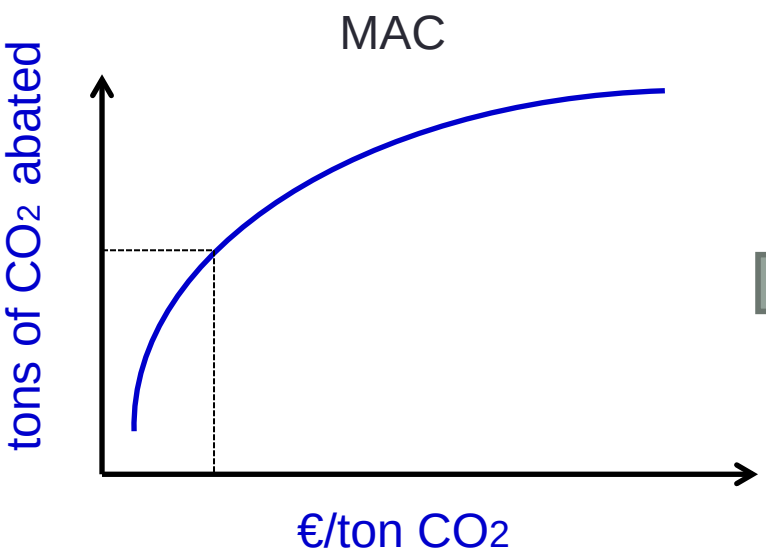
Background

- 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 ⇒ 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, but quantifies implied trade-offs.
- 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

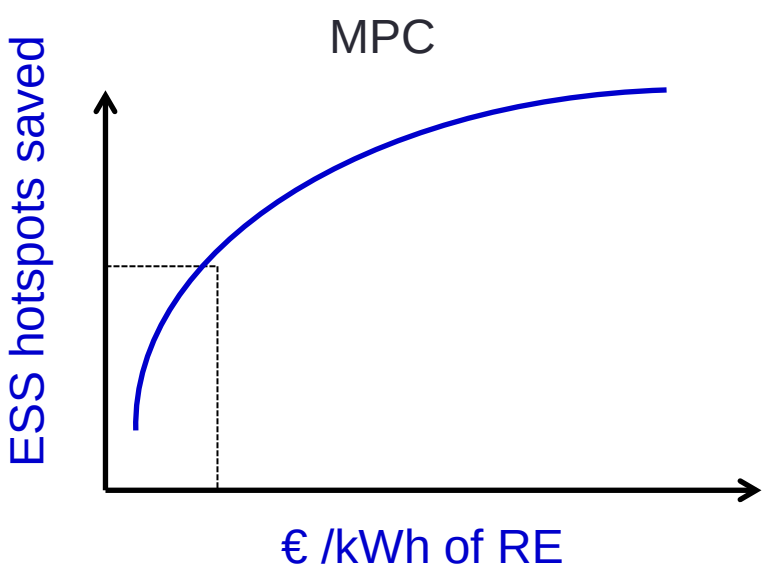
Marginal Protection Cost Concept

- 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



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.



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.

Methodology

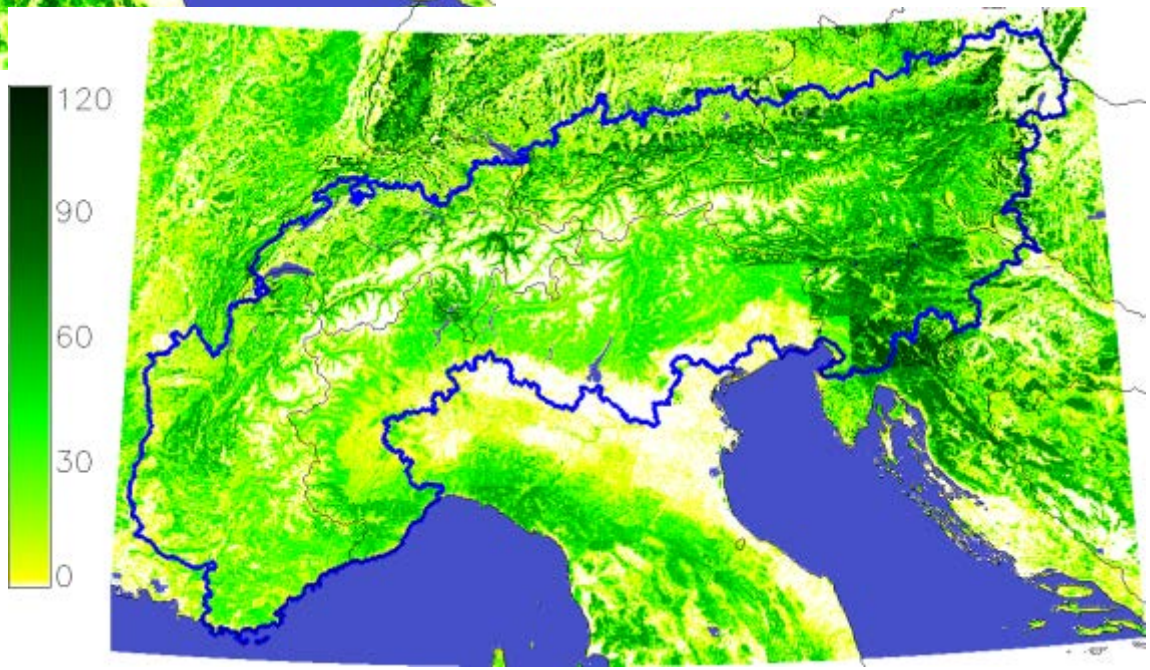
- Use the **BeWhere** Model* to optimize location and size of bioenergy units given the supply chain.
  - feedstock supply (incl. harvesting, transportation, etc.)
  - transportation routes/costs
  - trading possibilities
  - competition with other industries for feedstock
  - distribution networks
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

*Leduc et al. (2012). CHP or biofuel production in Europe? *Energy Procedia*, 20:40-49.

Technologies & Input Data

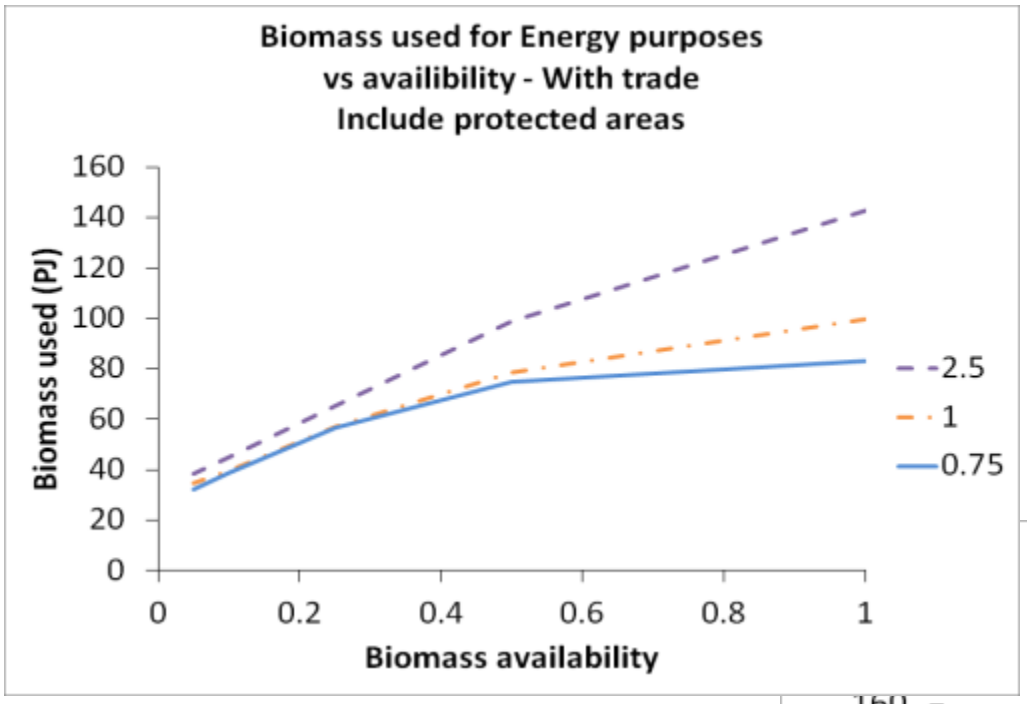
- Bioenergy technology: CHP, Gasification
- Bioenergy demand: based on national heat consumption (source: Werner 2006, Ecoheatcool WP1, WP4 / Berndes et al 2010)
- Transport networks, transportation cost (Source: National Imagery and Mapping Agency)
- Biodiversity hotspots / protected areas (Source: Econnect)
- Feedstocks: see map on next slide

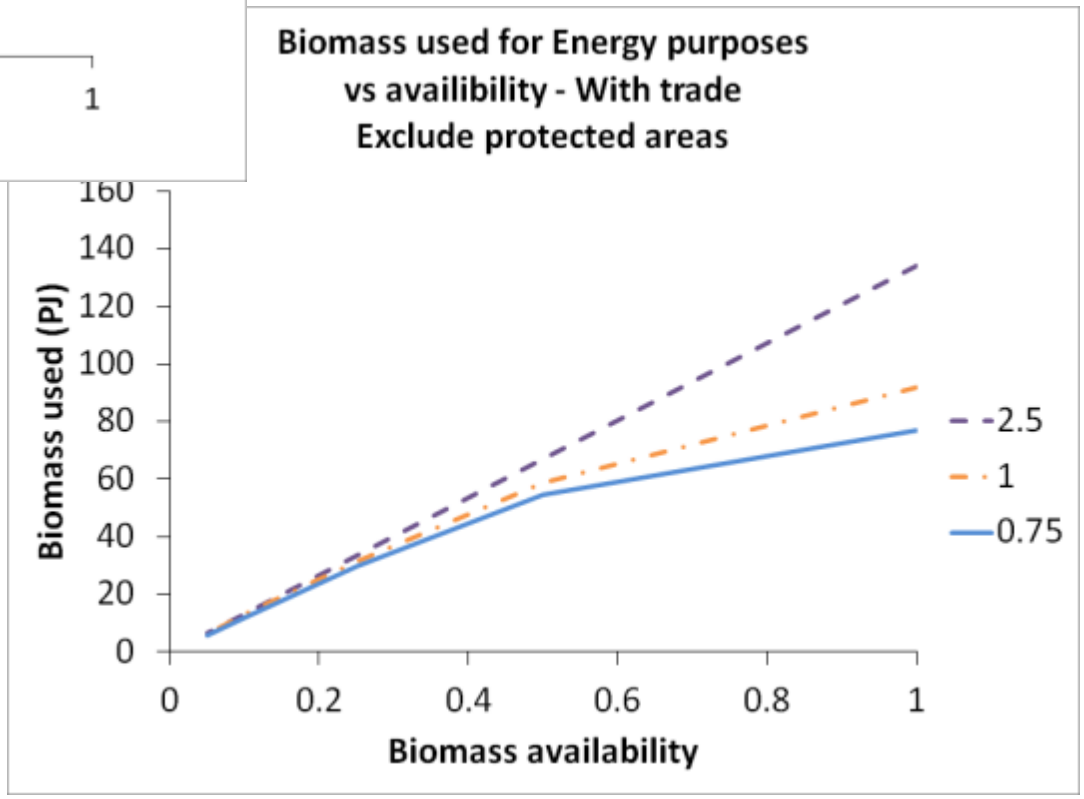
Biomass: current increment



Biomass: current stock

Source: Global Forestry Model (G4M)


Biomass used for Energy purposes
vs availibility - With trade
Include protected areas
Biomass used (PJ)
160
140
120
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
Biomass availability
2.5
1
0.75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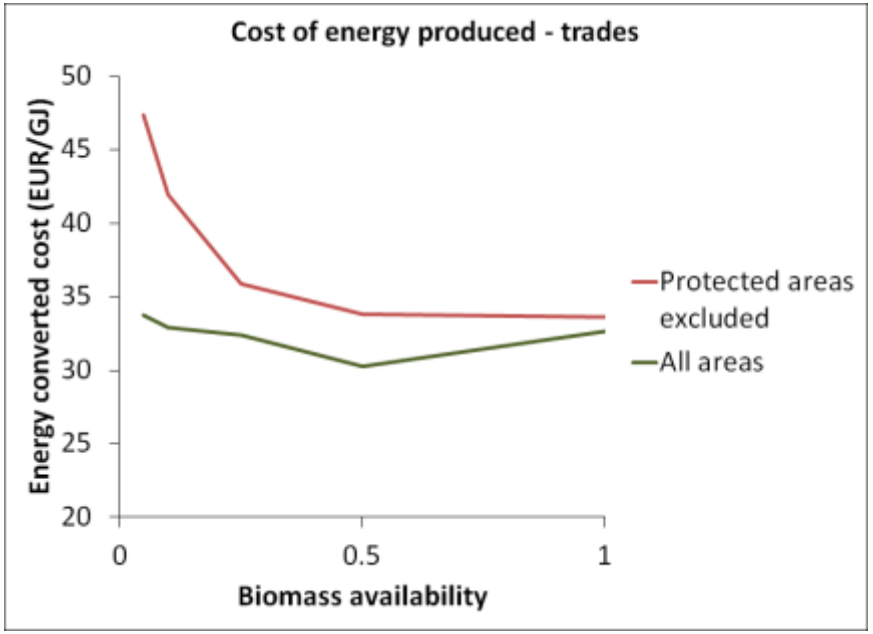
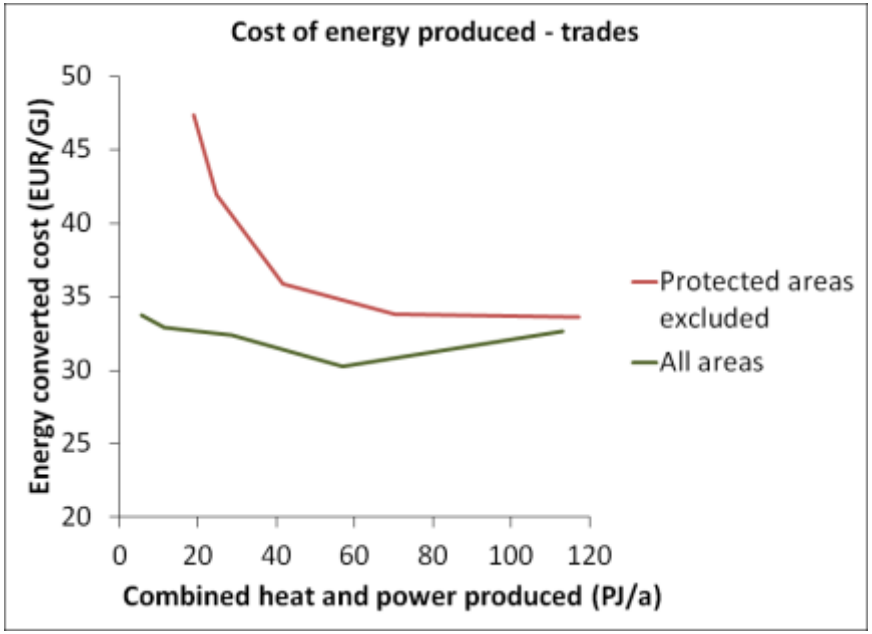
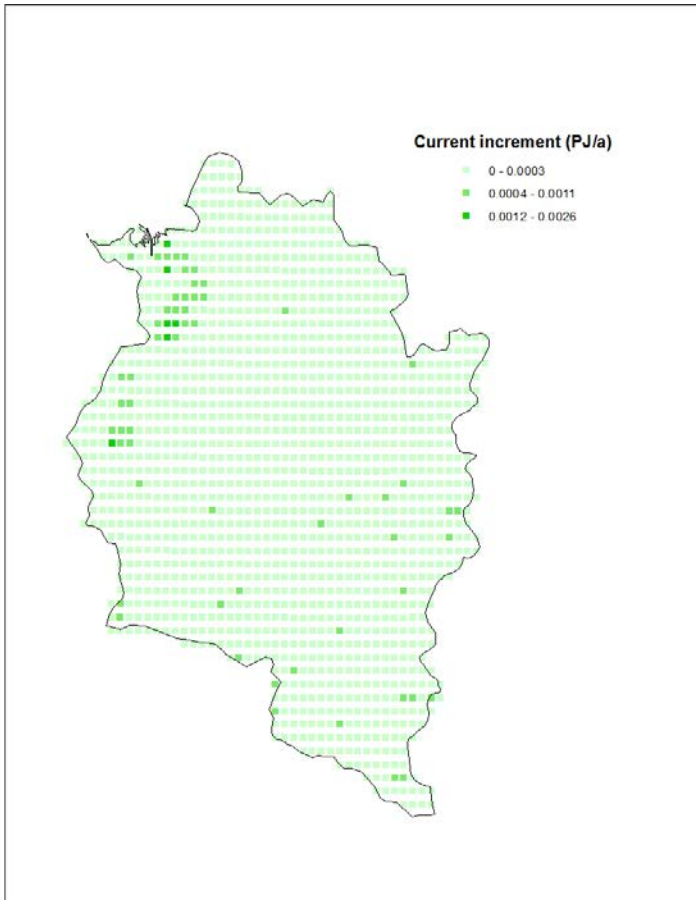
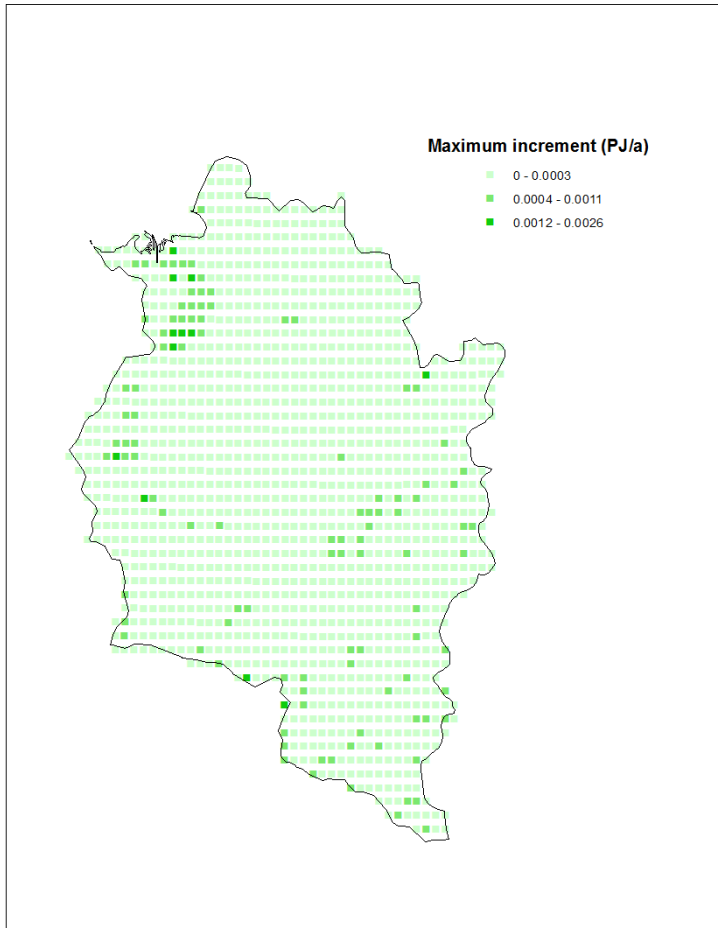
Bioenergy costs in the Alps with/out protection





Regional zoom: Vorarlberg's biomass

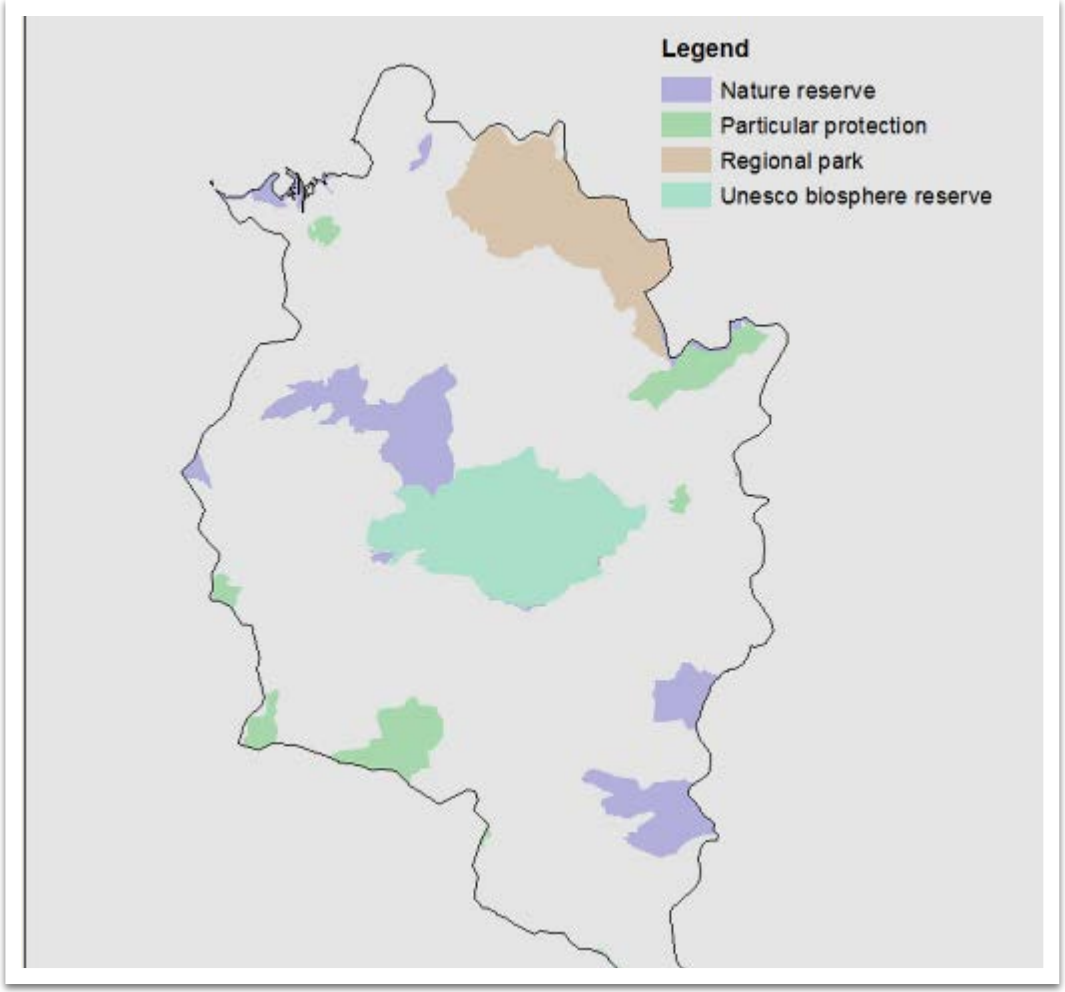




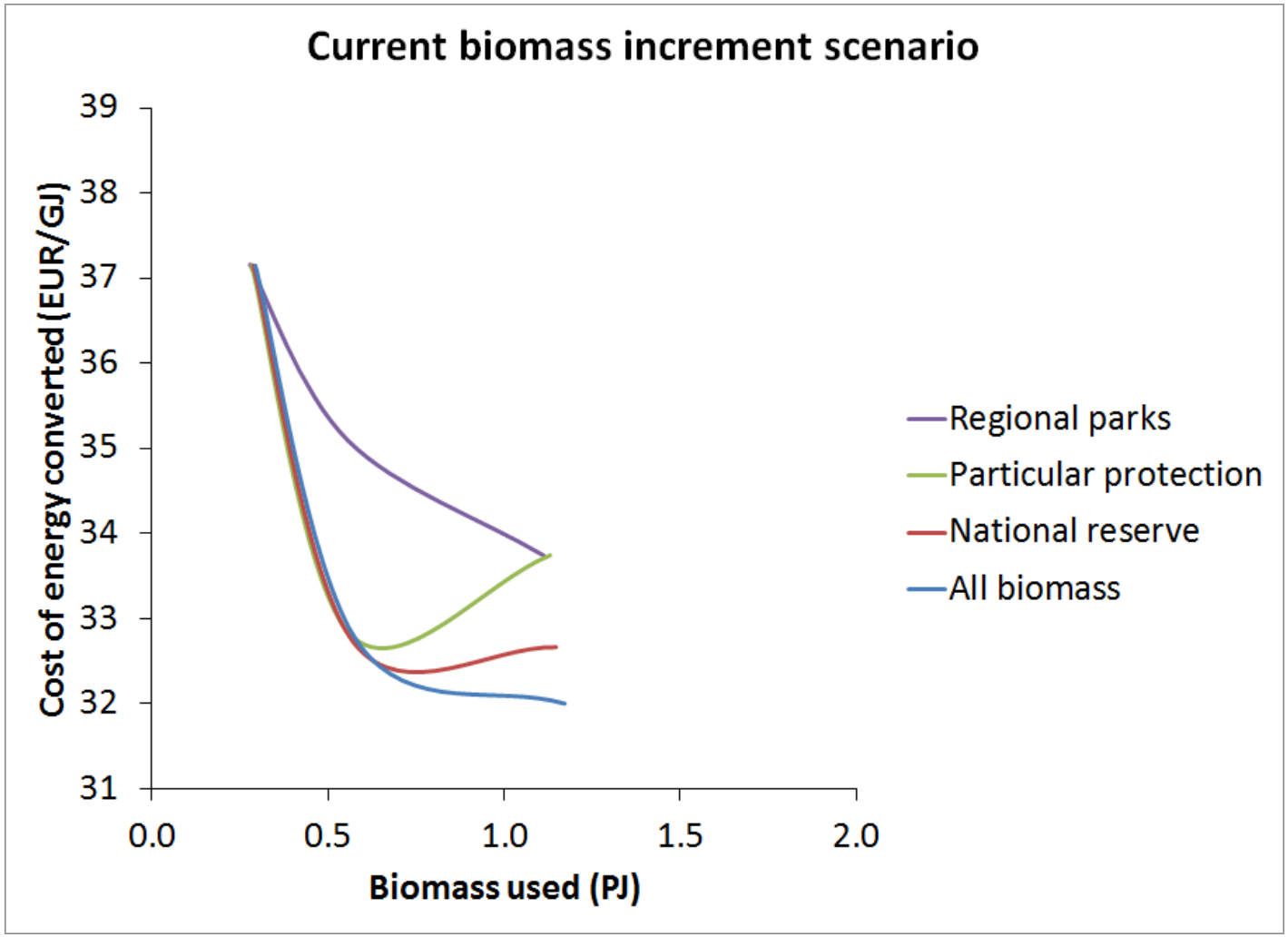
Vorarlberg's protected areas

- 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.



Marginal protection cost in Vorarlberg



Conclusions

- 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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This research is part of an Alpine Space project called recharge.green: http://www.recharge-green.eu/

recharge green

BALANCING ALPINE ENERGY AND NATURE