Modelling European Agriculture with Climate Change for Food Security

Integrated assessment of policy and climate change impacts

a case study on protein crop production in Austria

Economics of integrated assessment approaches for agriculture and the food sector
25-27 November 2014, Hurdalsjøen, Norway

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outline

- **context of analysis, stakeholders, policy relevance: protein crops**
- **research problem: integrated assessment**
- **data**
- **models**
- **scenarios and results**
- **discussion and outlook**

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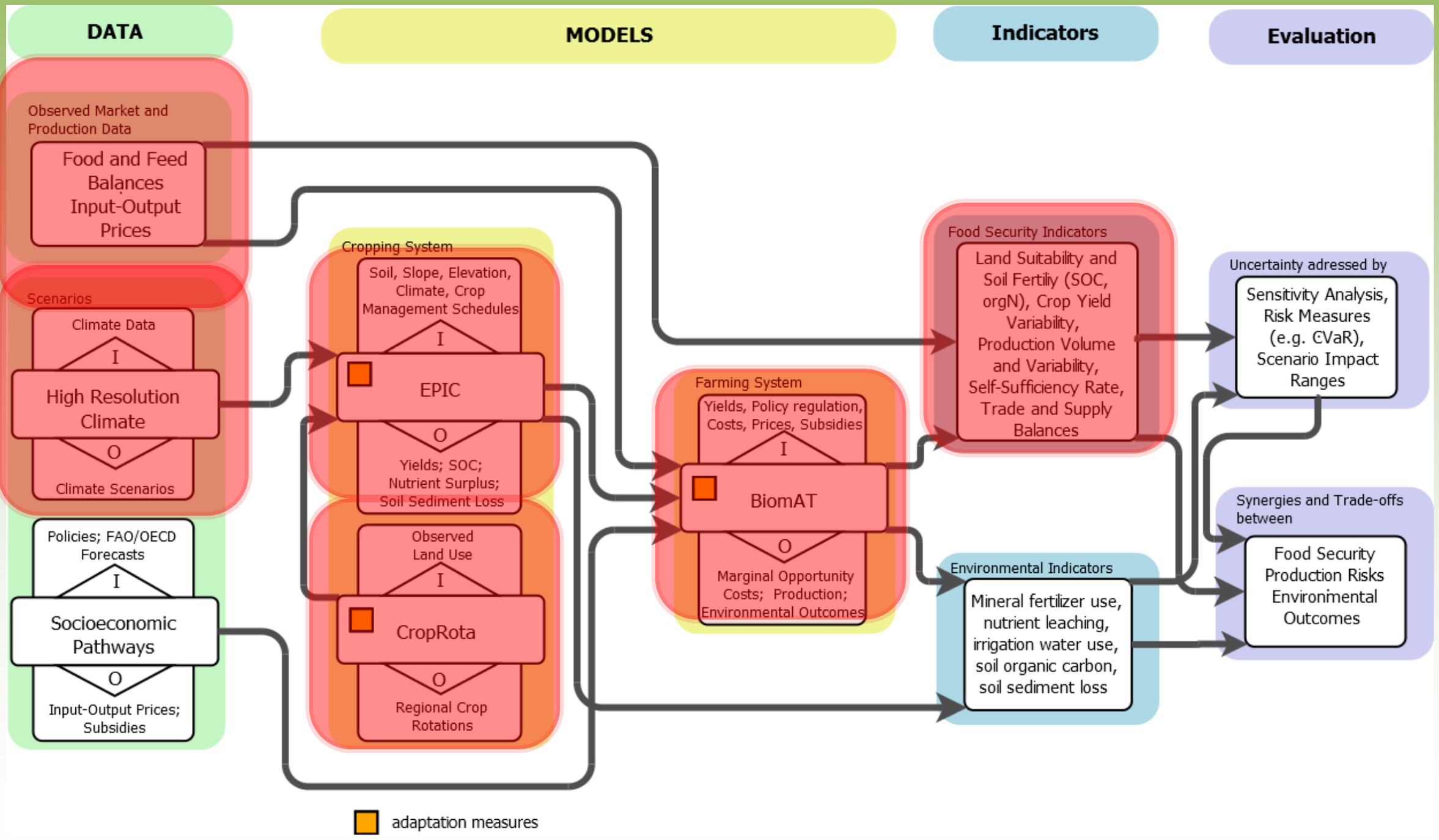
context of the analysis:

protein production and use case study on soy beans in Austria

integrated assessment modeling framework



Source: own construction

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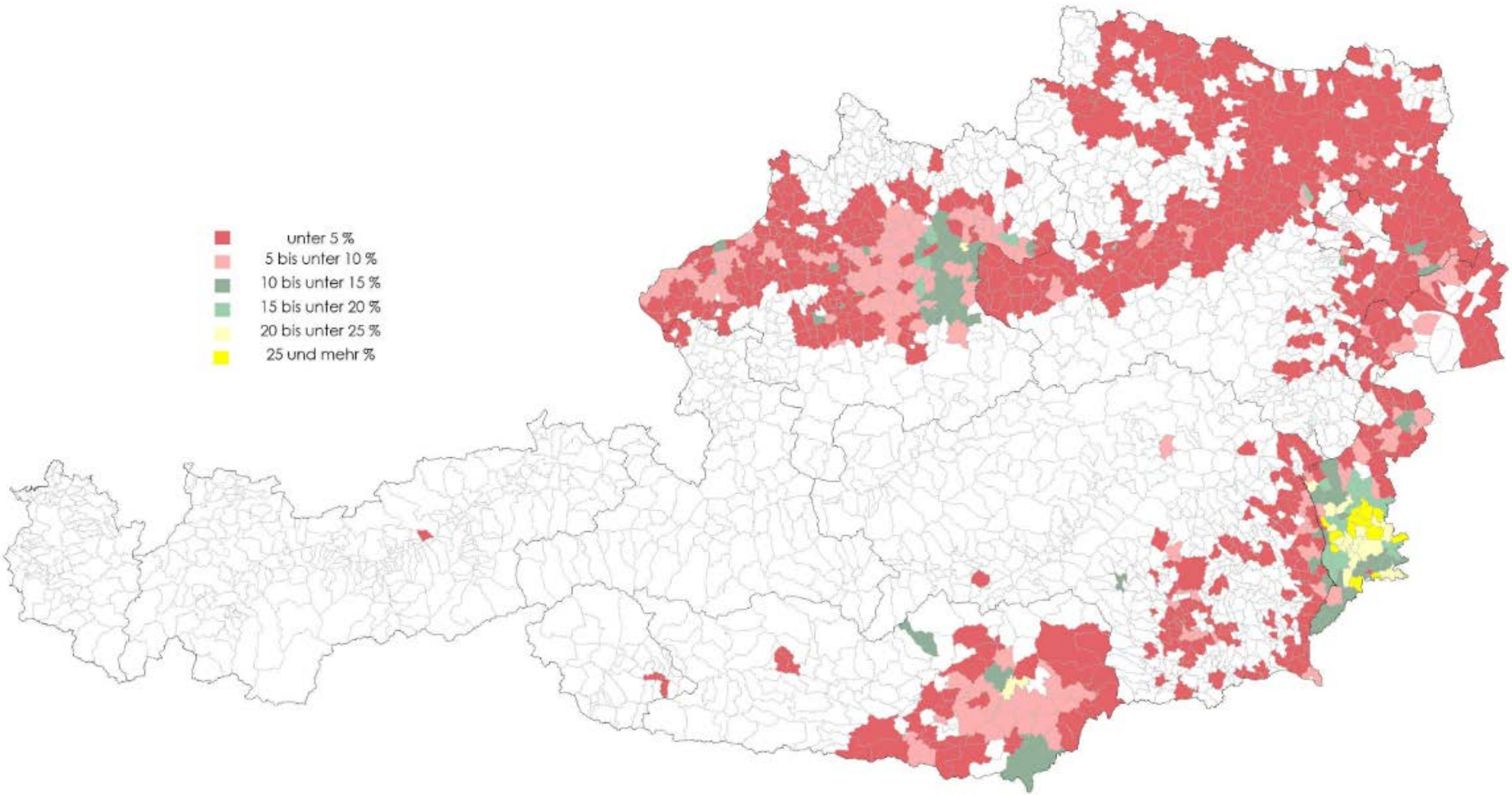
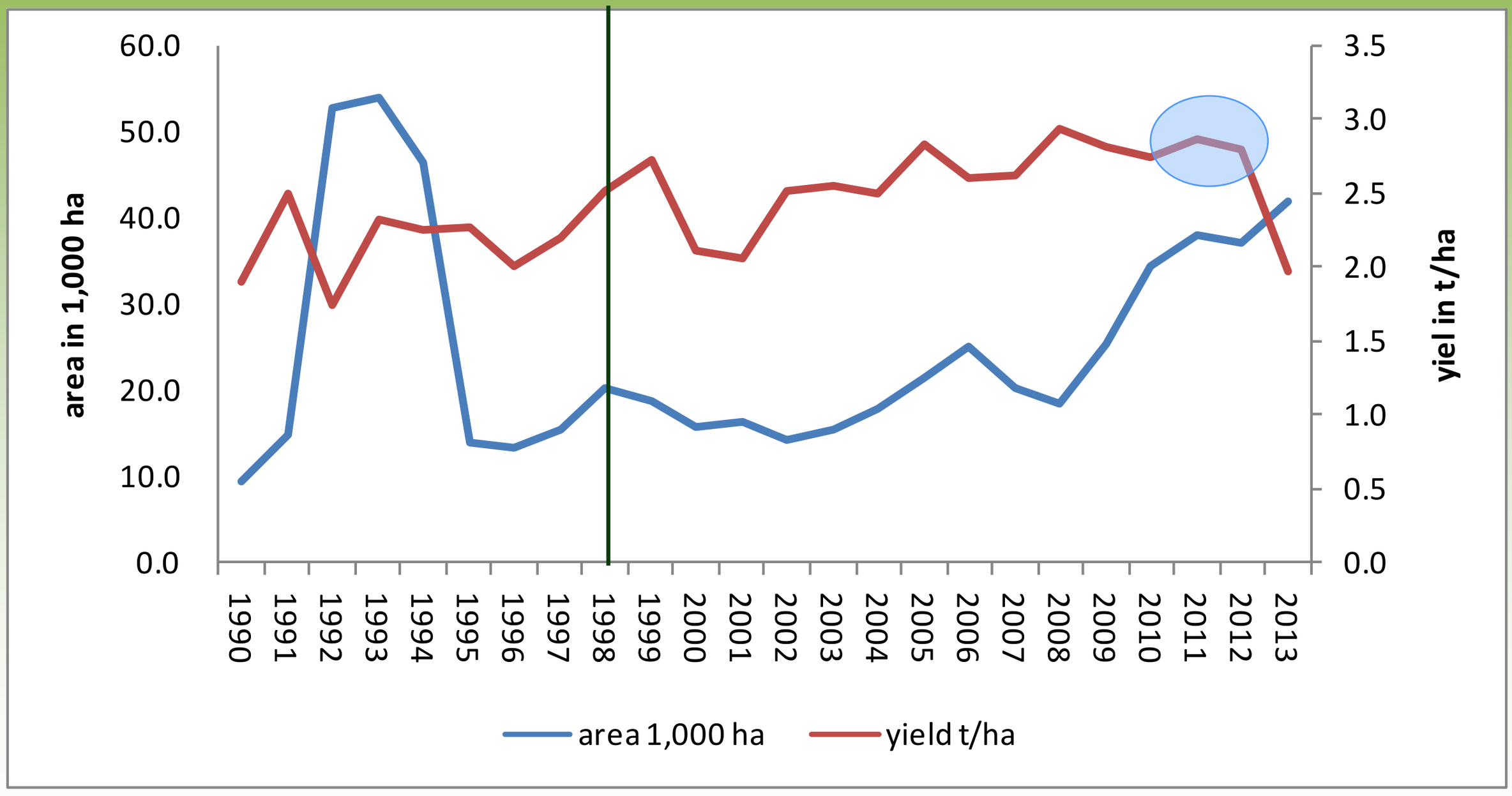
data

regional production of soy 2012



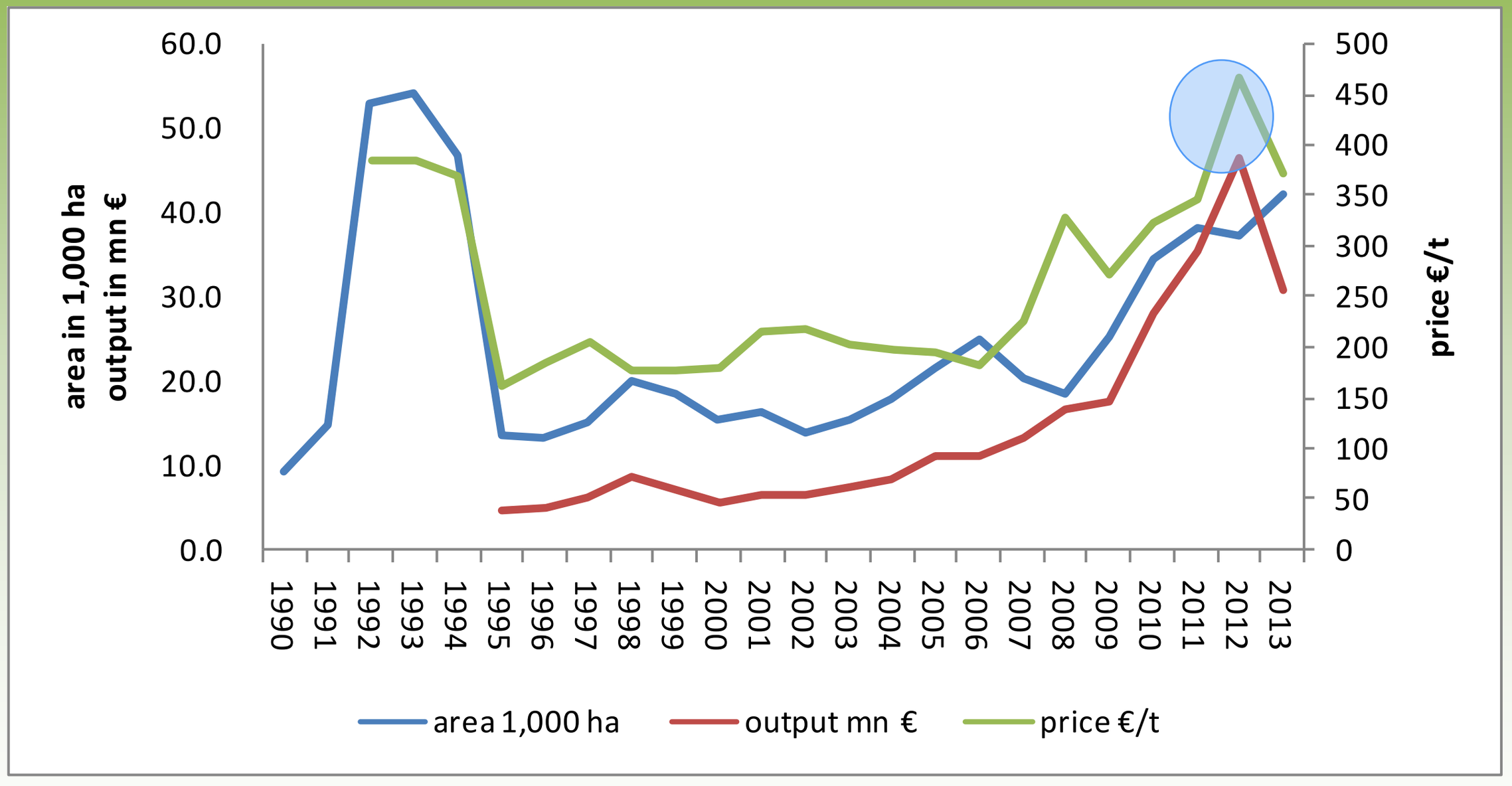
Source: STAT, Agrarstrukturerhebung 2012

soy bean production in AT



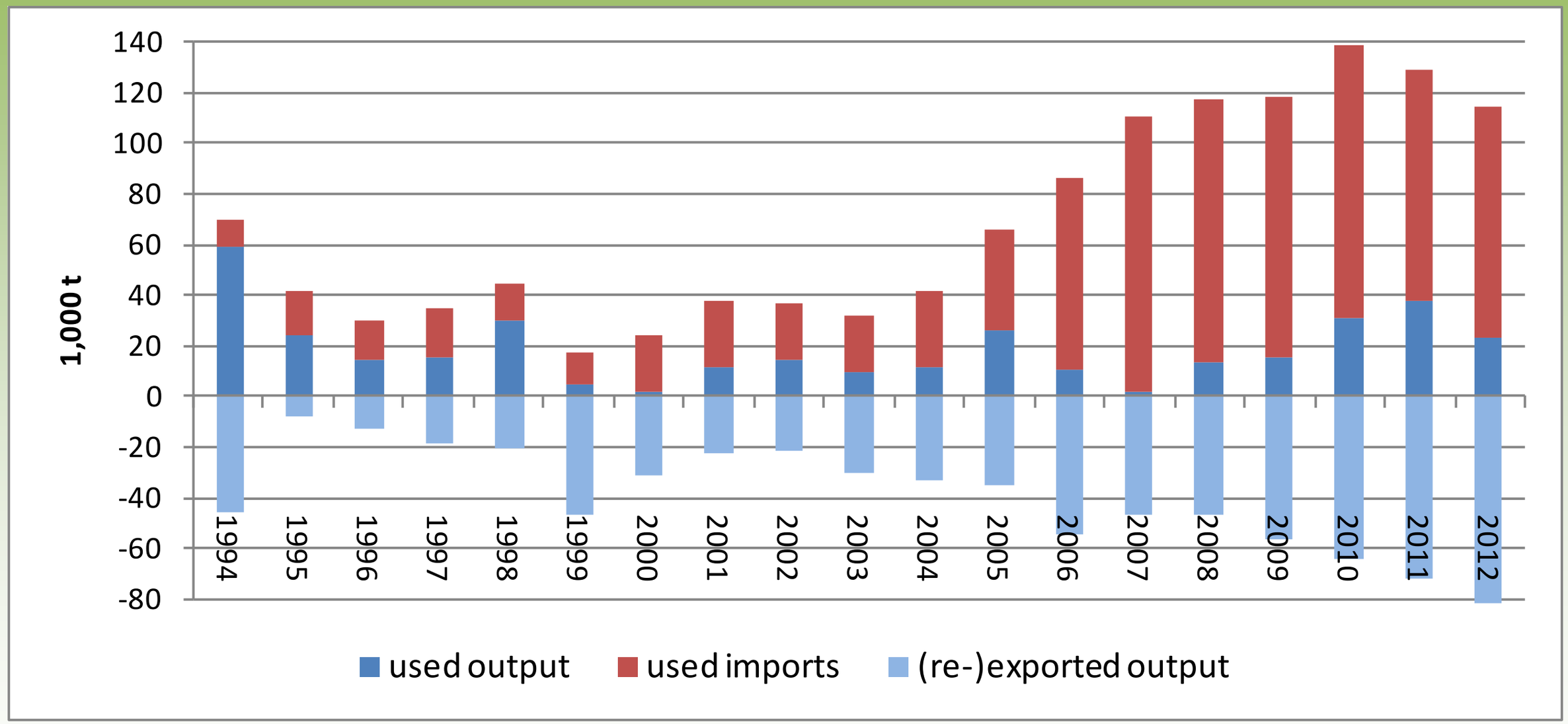
Source: STAT, Erntestatistik

soy bean output in AT



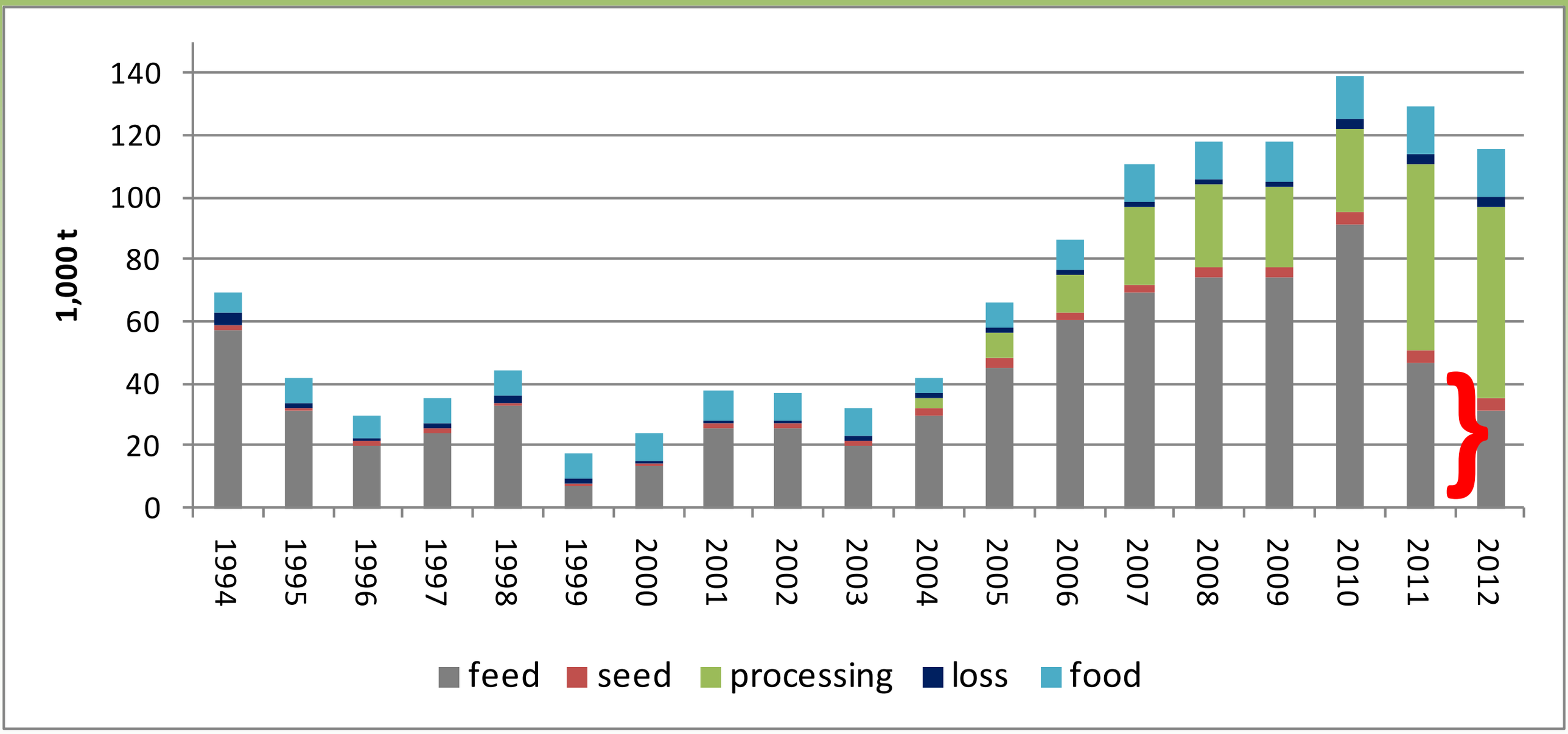
Source: STAT, EAA

soy bean balance in AT



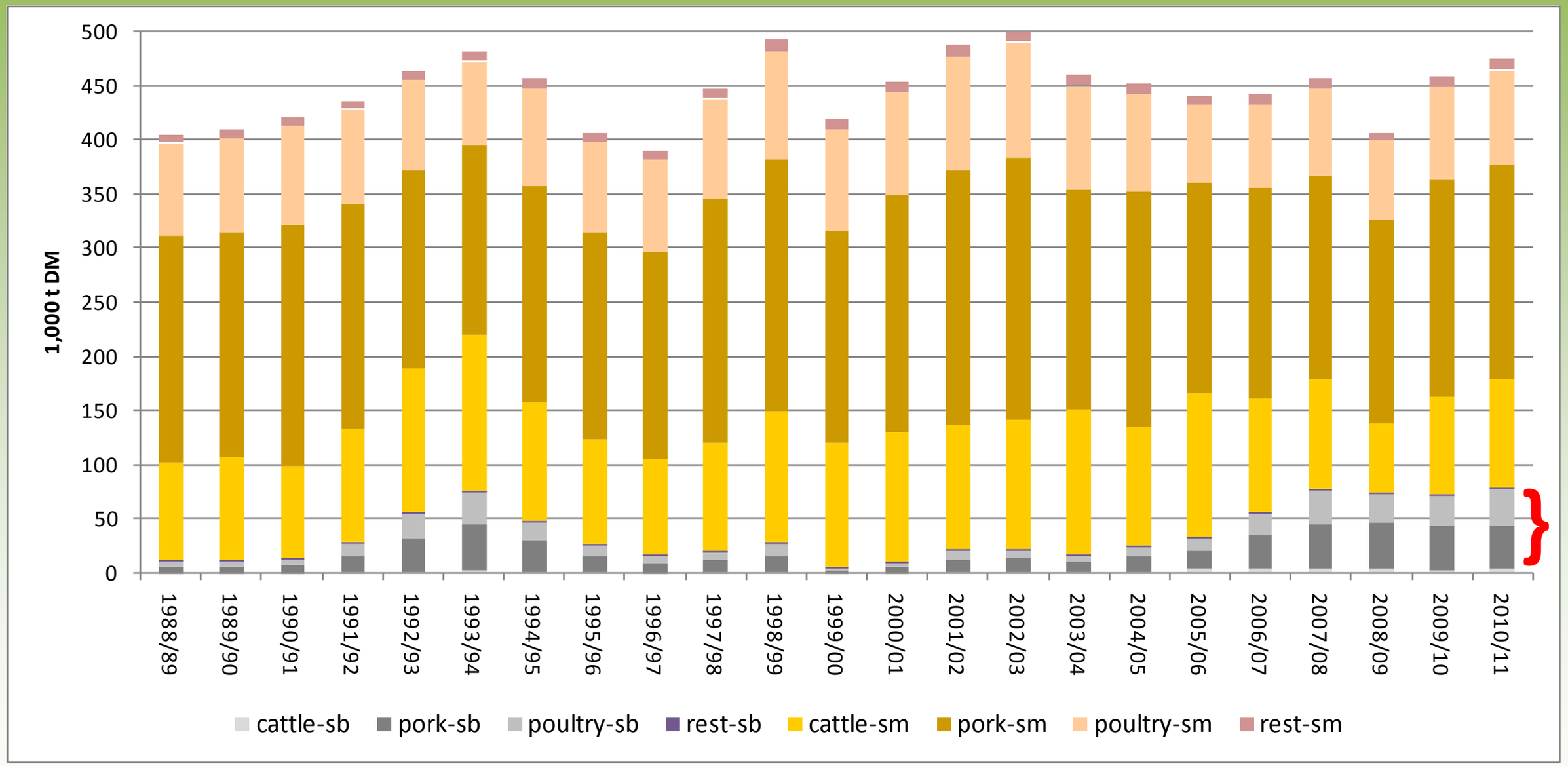
Source: STAT, Versorgungsbilanz, various years

soy bean use in AT



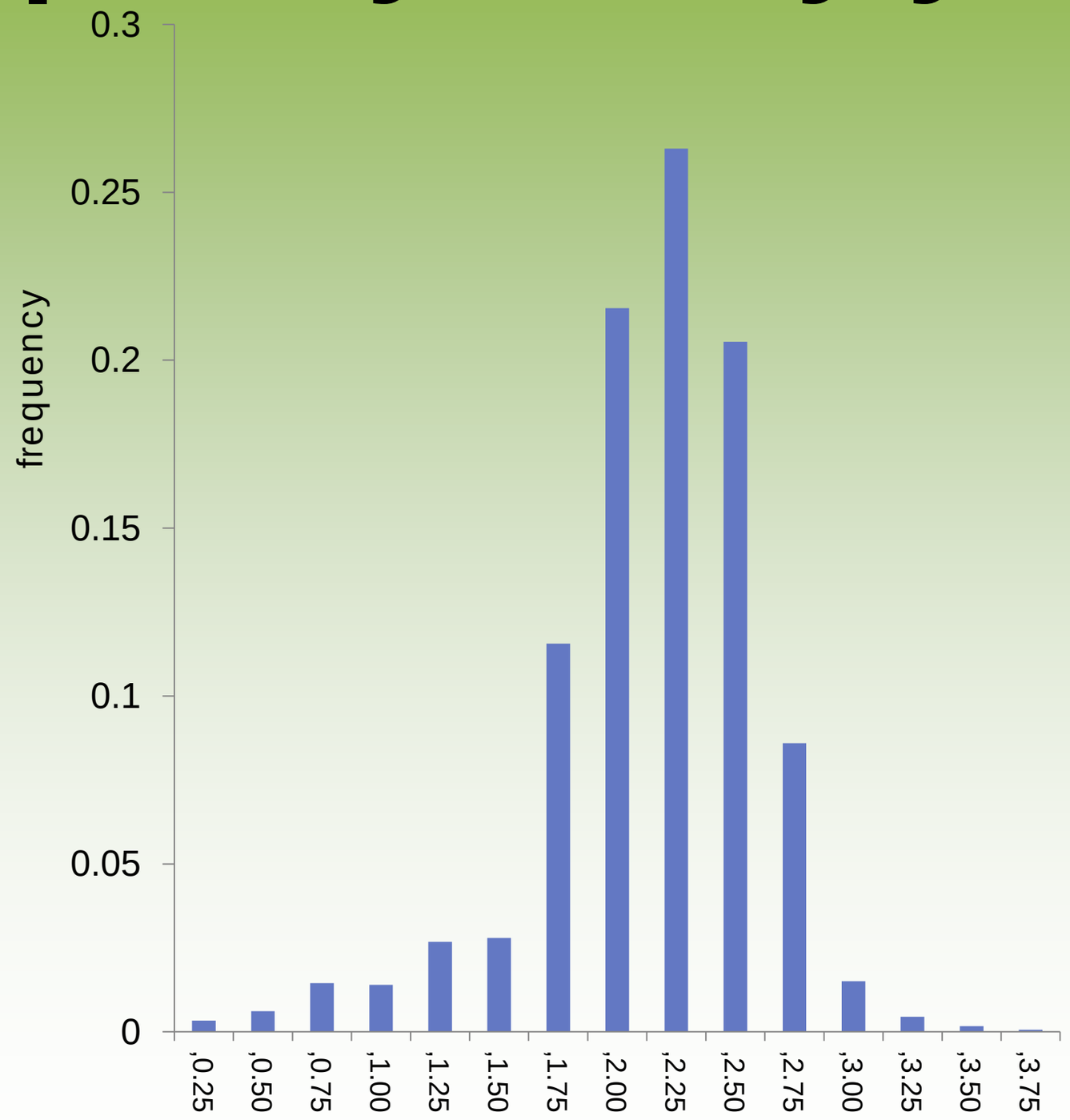
Source: STAT, Versorgungsbilanz, various years

soy bean & soy meal feed in AT



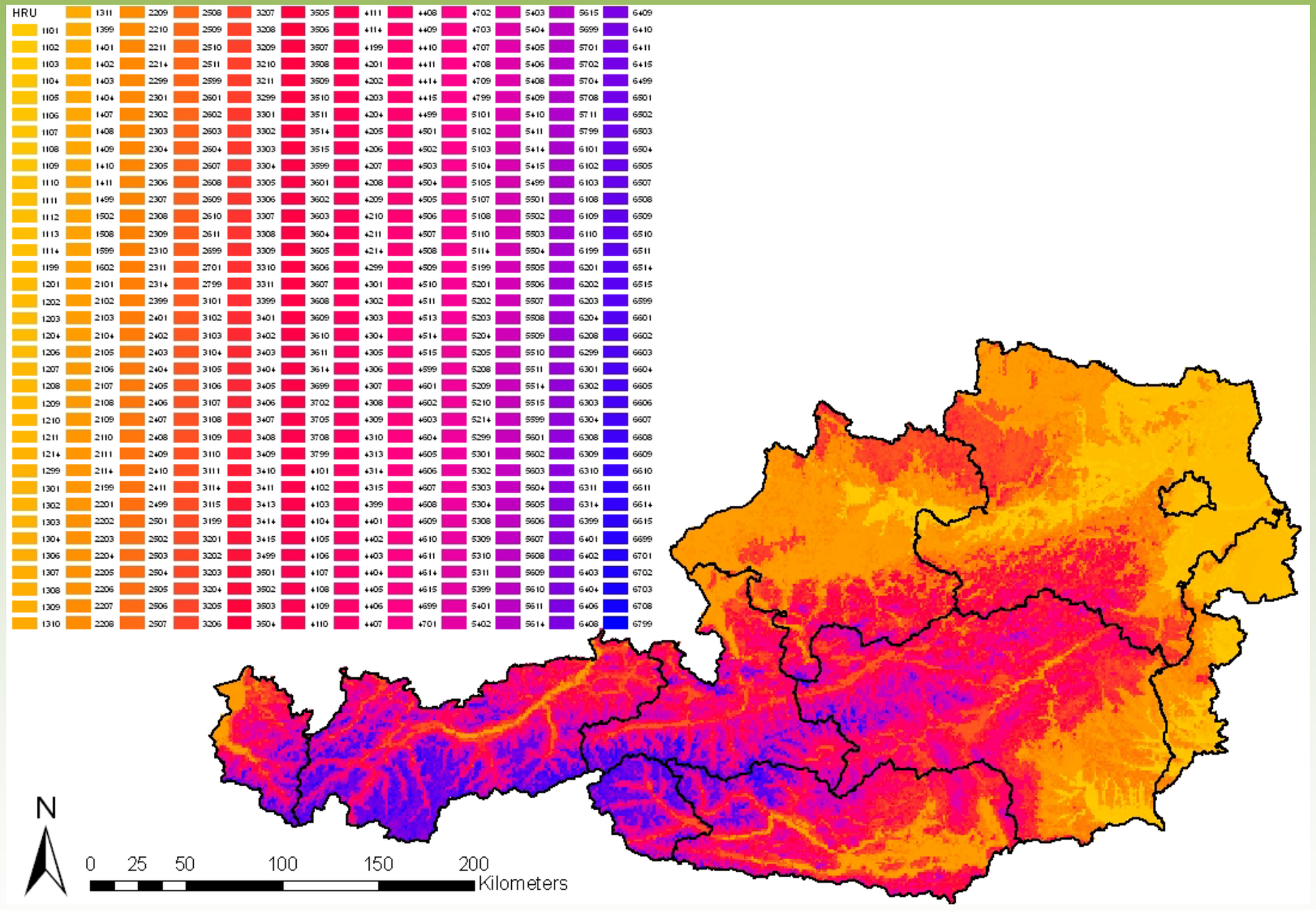
Source: STAT, Futterbilanz, various years

farm level: frequency of soy yields



Source: FADN, LBG, BMLFUW, own calculations ; observations for 1998-2012

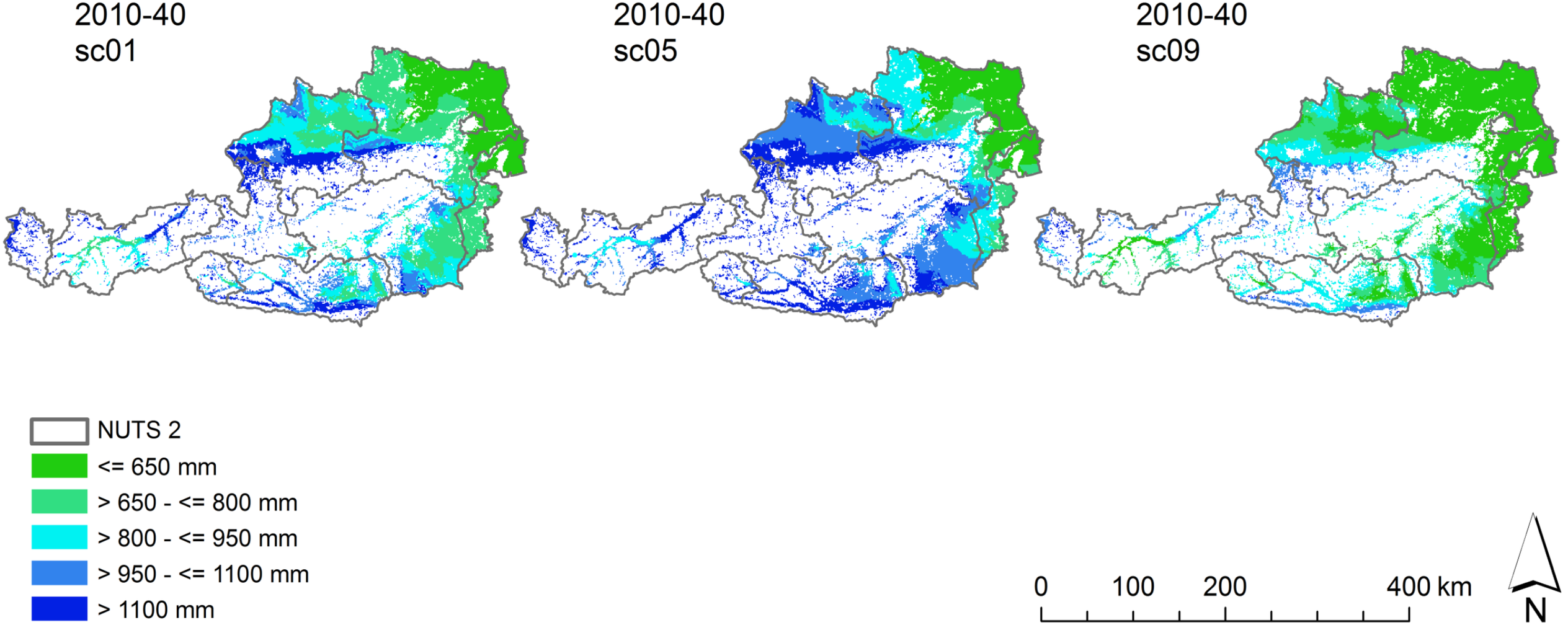
spatial heterogeneity
HRU Homogenous Response Units



Source: own construction

Data: Past and future climates

- **period 1975-2005: observed weather data**
- **period 2010-2040: 5 climate change scenarios (Strauss et al. 2012, 2013): rising trend in temperature (+1.5 °C), different precipitation scenarios**



Source: own construction

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policy response:

goal stimulation of protein crops

greening of CAP 2013 reform

protein crops are more competitive

concern about CC

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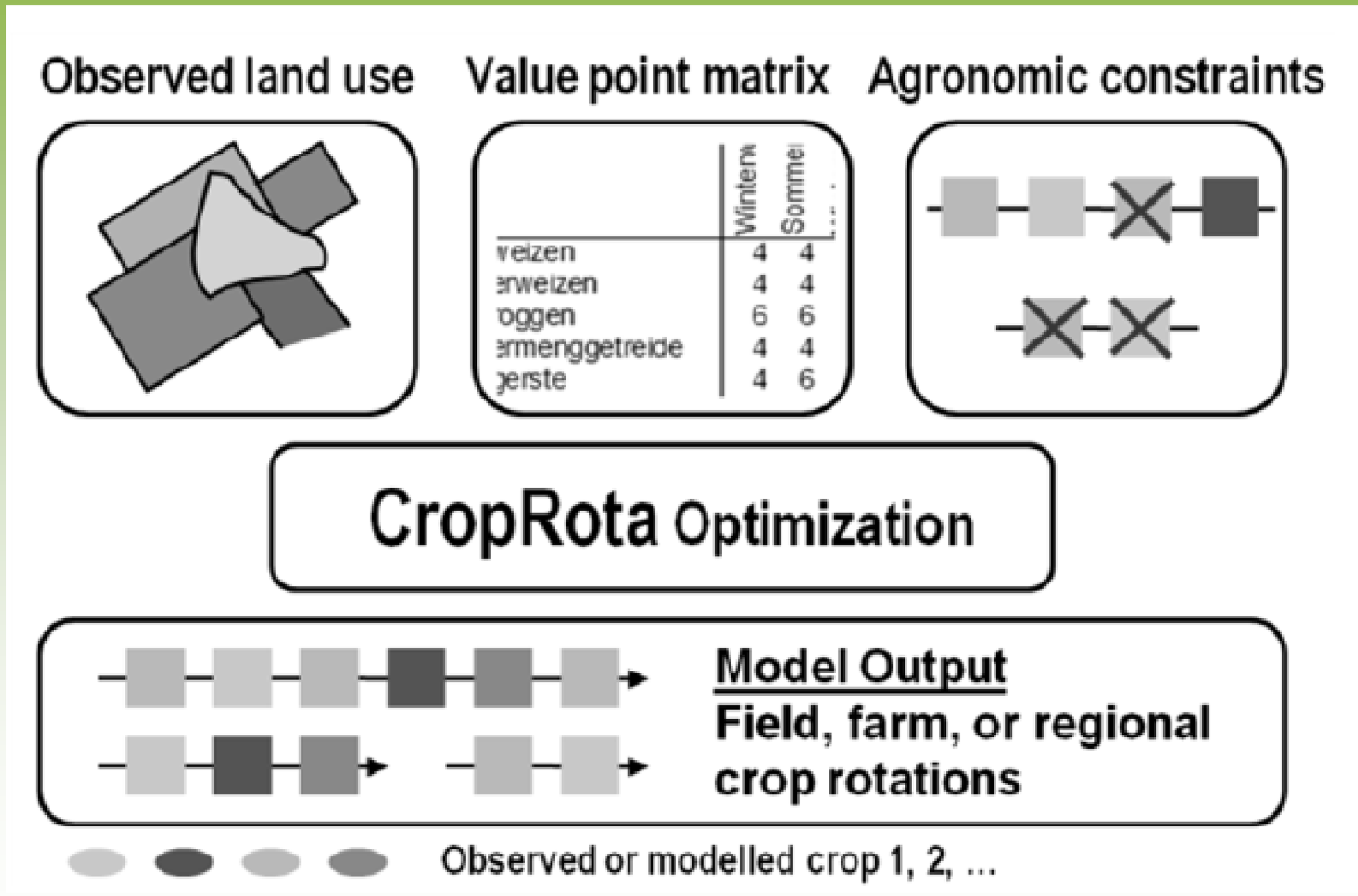
models

CROP ROTA



Source: Schönhart, Schmid, Schneider, 2009

CROP ROTA

$$max.TotValue =$$

$$\frac{1}{2}\sum_{\dot{c}}[p_{\dot{c},\dot{c}}\ R^{1}_{\dot{c}}] + \sum_{\dot{c},\ddot{c}}[\frac{1}{2}\ p_{\dot{c},\ddot{c}}\ (R^{2}_{\dot{c},\ddot{c}} + R^{2}_{\ddot{c},\dot{c}})] + \sum_{\dot{c},\ddot{c},\dddot{c}}[\frac{1}{3}\ p_{\dot{c},\ddot{c}}\ (R^{3}_{\dot{c},\ddot{c},\dddot{c}} + R^{3}_{\ddot{c},\dddot{c},\dot{c}} + R^{3}_{\dddot{c},\dot{c},\ddot{c}})]$$

$$+ \sum_{\dot{c},\ddot{c},\dddot{c},\ddddot{c}}[\frac{1}{4}\ p_{\dot{c},\ddot{c}}\ (R^{4}_{\dot{c},\ddot{c},\dddot{c},\ddddot{c}} + R^{4}_{\ddot{c},\dddot{c},\ddddot{c},\dot{c}} + R^{4}_{\dddot{c},\ddddot{c},\dot{c},\ddot{c}} + R^{4}_{\ddddot{c},\dot{c},\ddot{c},\dddot{c}})]$$

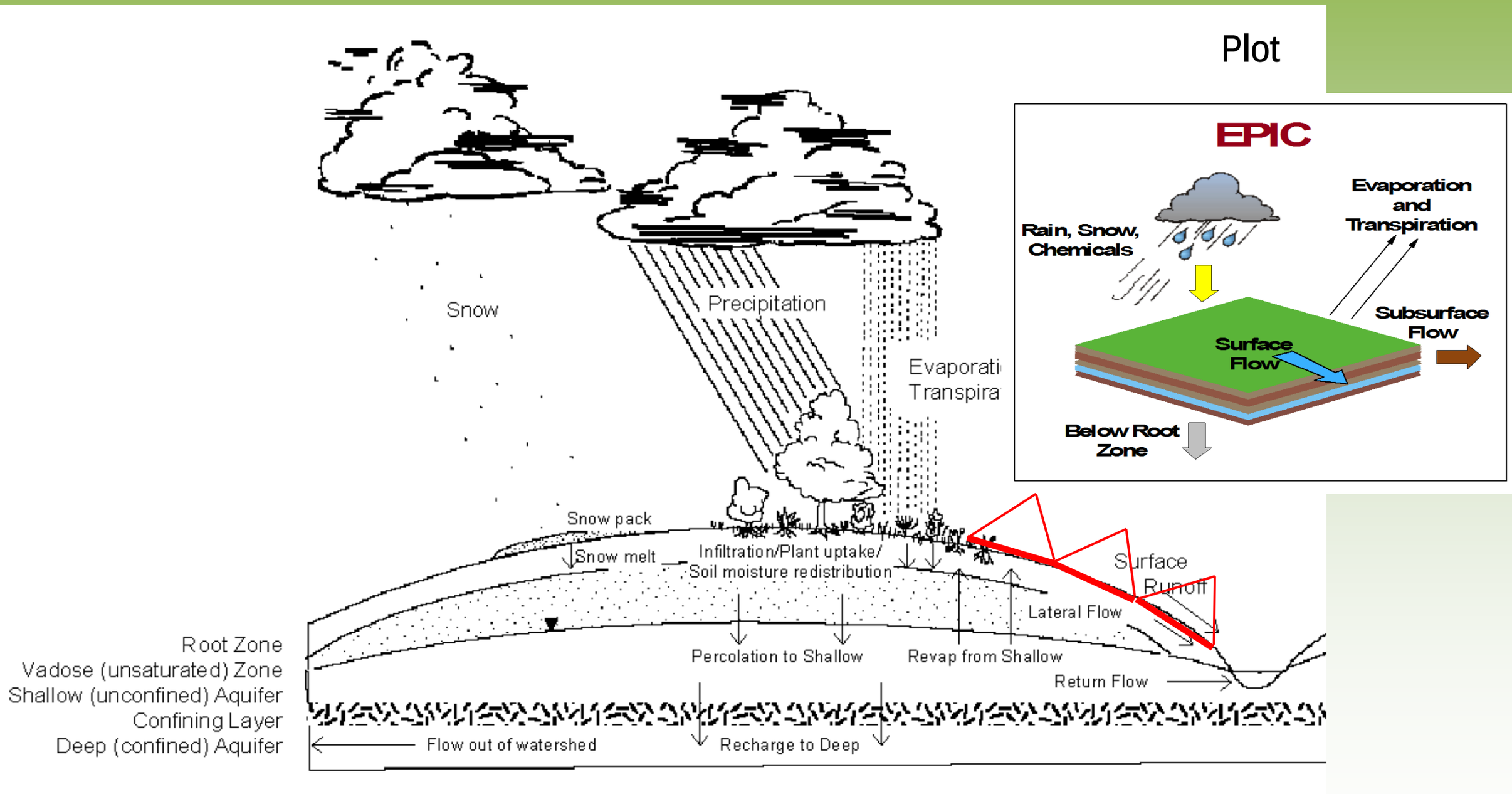
$$+ \sum_{\dot{c},\ddot{c},\dddot{c},\ddddot{c},\ddddot{c}}[\frac{1}{5}\ p_{\dot{c},\ddot{c}}\ (R^{5}_{\dot{c},\ddot{c},\dddot{c},\ddddot{c},\ddddot{c}} + R^{5}_{\ddot{c},\dot{c},\ddot{c},\dddot{c},\ddddot{c}} + R^{5}_{\dot{c},\ddot{c},\dot{c},\ddot{c},\dddot{c}} + R^{5}_{\dddot{c},\ddot{c},\dddot{c},\dot{c},\ddot{c}} + R^{5}_{\ddot{c},\dddot{c},\ddot{c},\ddddot{c},\dot{c}})]$$

$$+ \sum_{\dot{c},\ddot{c},\dddot{c},\ddddot{c},\ddddot{c},\dddddot{c}}[\frac{1}{6}\ p_{\dot{c},\ddot{c}}\ (R^{6}_{\dot{c},\ddot{c},\dddot{c},\ddddot{c},\ddddot{c},\dddddot{c}} + R^{6}_{\dddot{c},\dot{c},\ddot{c},\dddot{c},\ddddot{c},\ddddot{c}} + R^{6}_{\dddot{c},\dddot{c},\dot{c},\ddot{c},\dddot{c},\ddddot{c}} + R^{6}_{\ddddot{c},\dddot{c},\ddddot{c},\dot{c},\ddot{c},\dddot{c}} + R^{6}_{\ddddot{c},\dddot{c},\ddddot{c},\dddot{c},\dddot{c},\dot{c}} + R^{6}_{\ddddot{c},\dddot{c},\ddddot{c},\dddot{c},\dddot{c},\dot{c}})]$$

$$- \sum_{\dot{c}}[(T_{\dot{c}} + U_{\dot{c}}) * d]$$

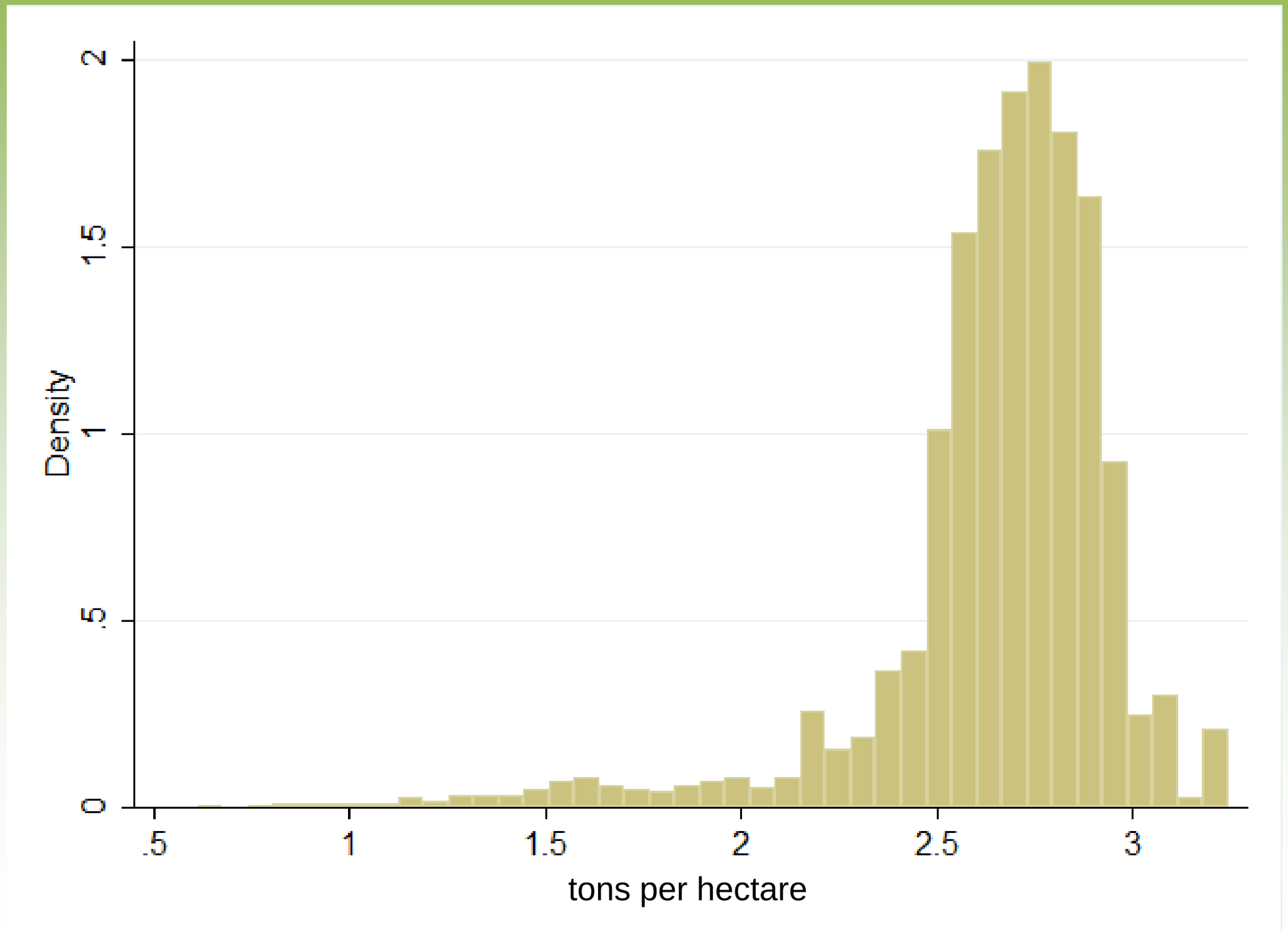
Source: Schönhart, Schmid, Schneider, 2009

Bio-physical process model EPIC



Source: own construction

simulated protein crop yields 1975-2000



Source: own results

BiomAT

$$max\ TGM_i = \sum_m \pi_{i,m}\, x_{i,m} \qquad \forall\ i$$

$$s.t. \sum_m \left(A_{i,m}\, x_{i,m}\right) \leq b_i \qquad \forall\ i$$

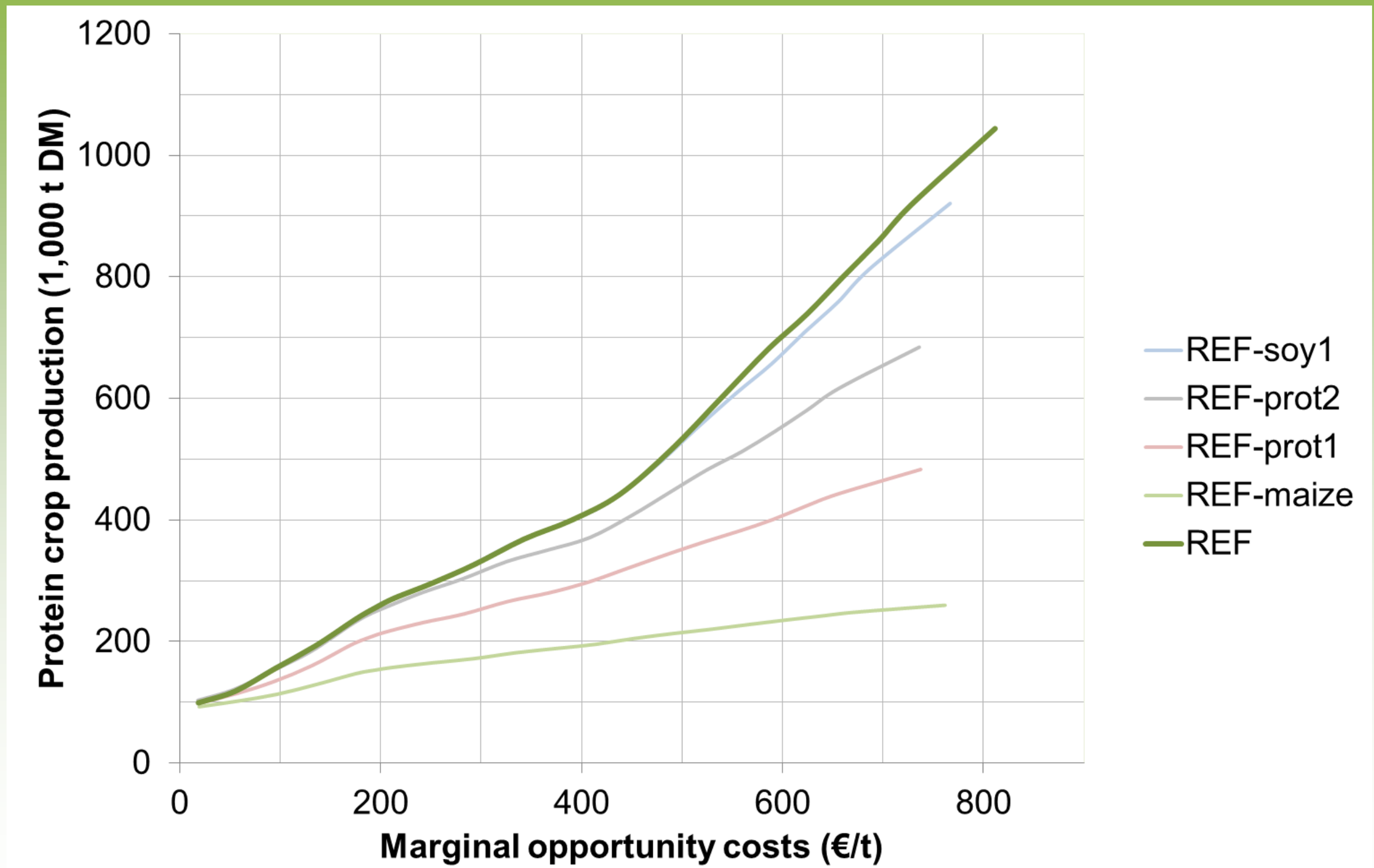
TGM	total gross margin
π	average gross margin in €/ha
i	grid cells (I=40,244)
m	management variants (up to 32 per i)
x	level of crop production in t
A	technical coefficients
b	resource constraints

Source: Asamer, Stürmer, Strauss, Schmid, 2011

scenarios

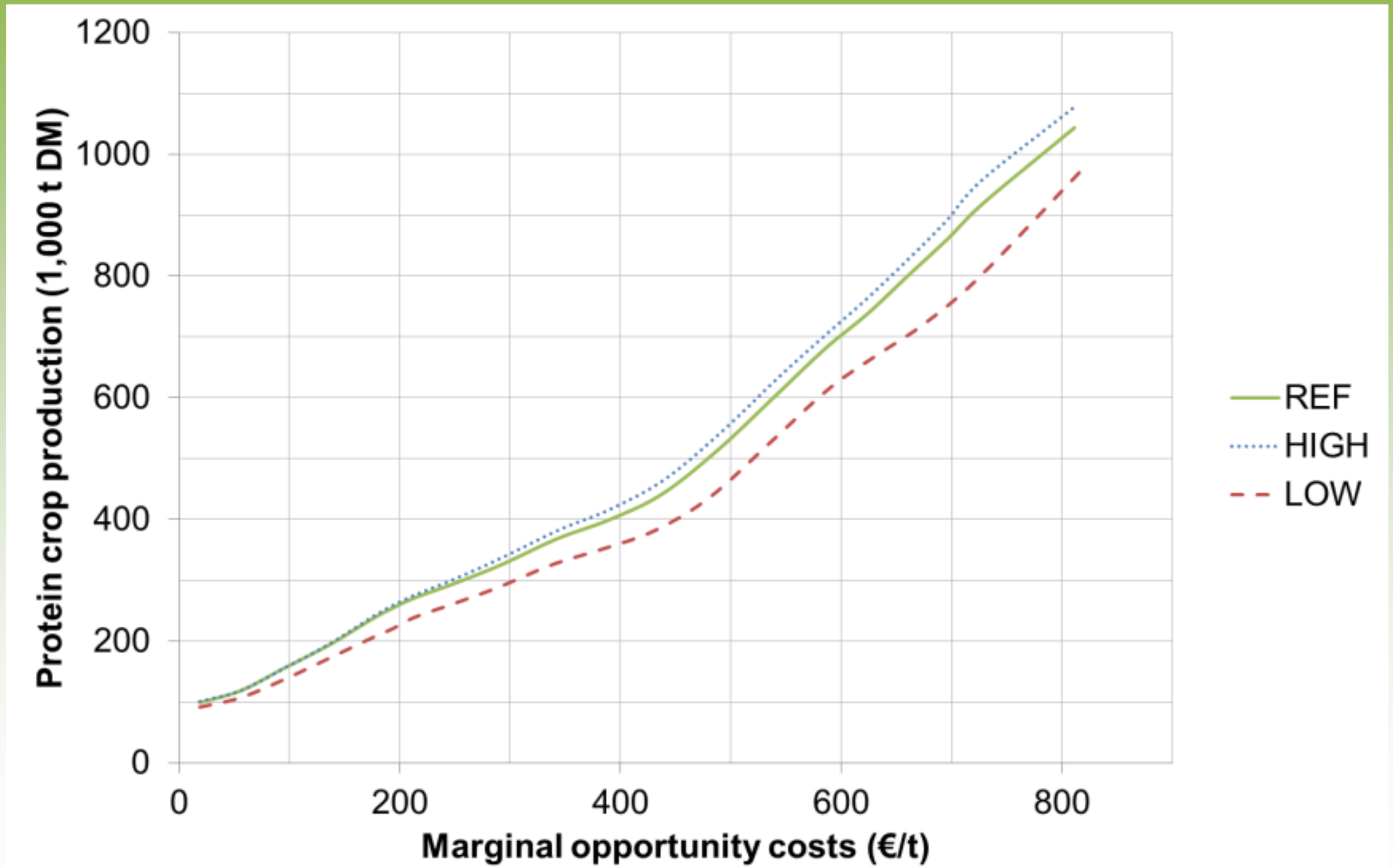
- **future CC: 1.5°c +/- 20% precipitation**
- **increasing prices of protein crops**
- **c.p.: other prices/costs (2006/2008)**
- **more land (proviously set aside land) for protein crops**
- **management variants *m*:**
  - considered: low/moderate/high intensity, irrigation
  - simulated: **more choices** on crop rotations

results:+/- management variants



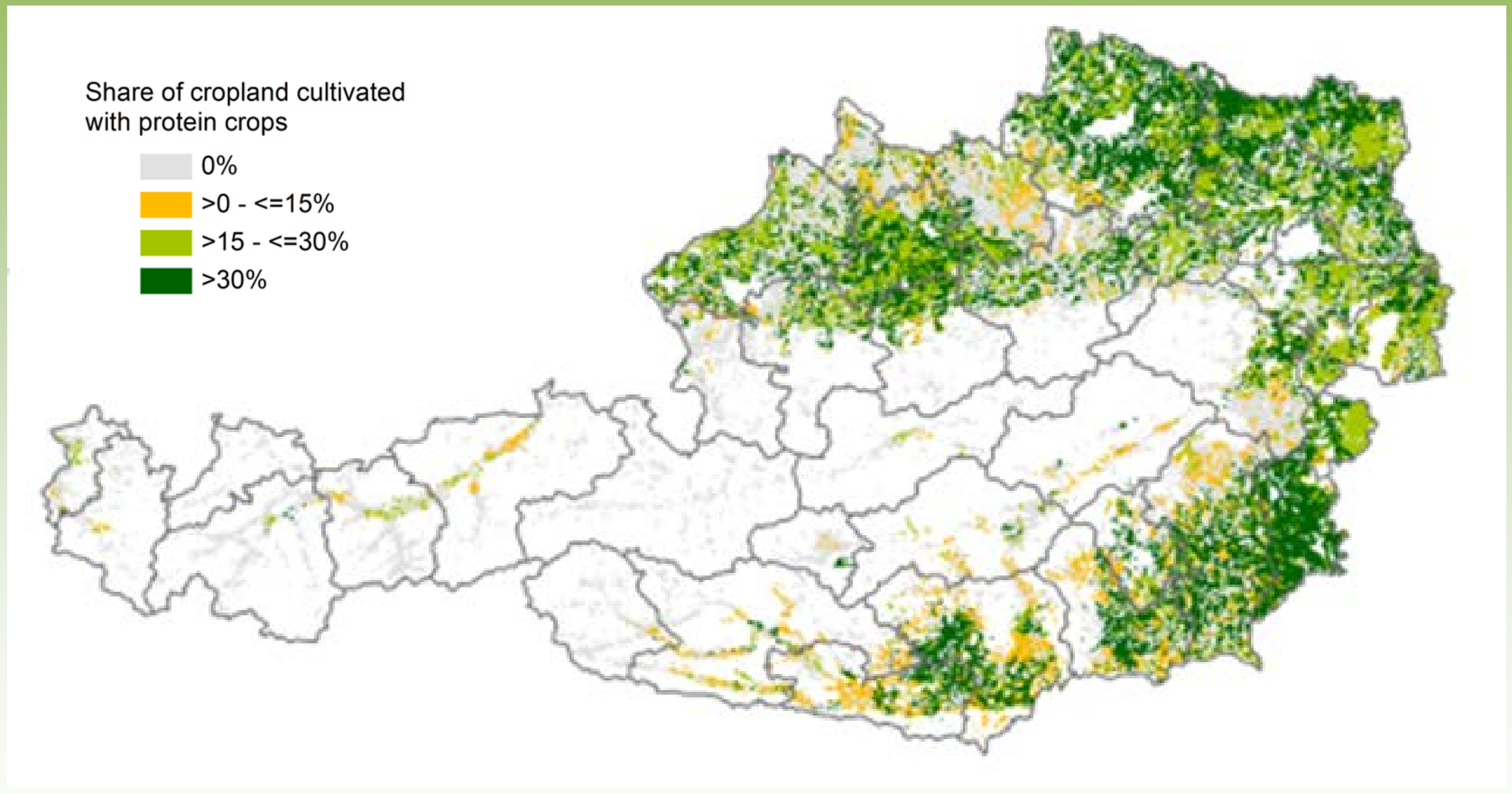
Source: own construction

results: ... plus CC



Source: own construction

extreme scenario S20

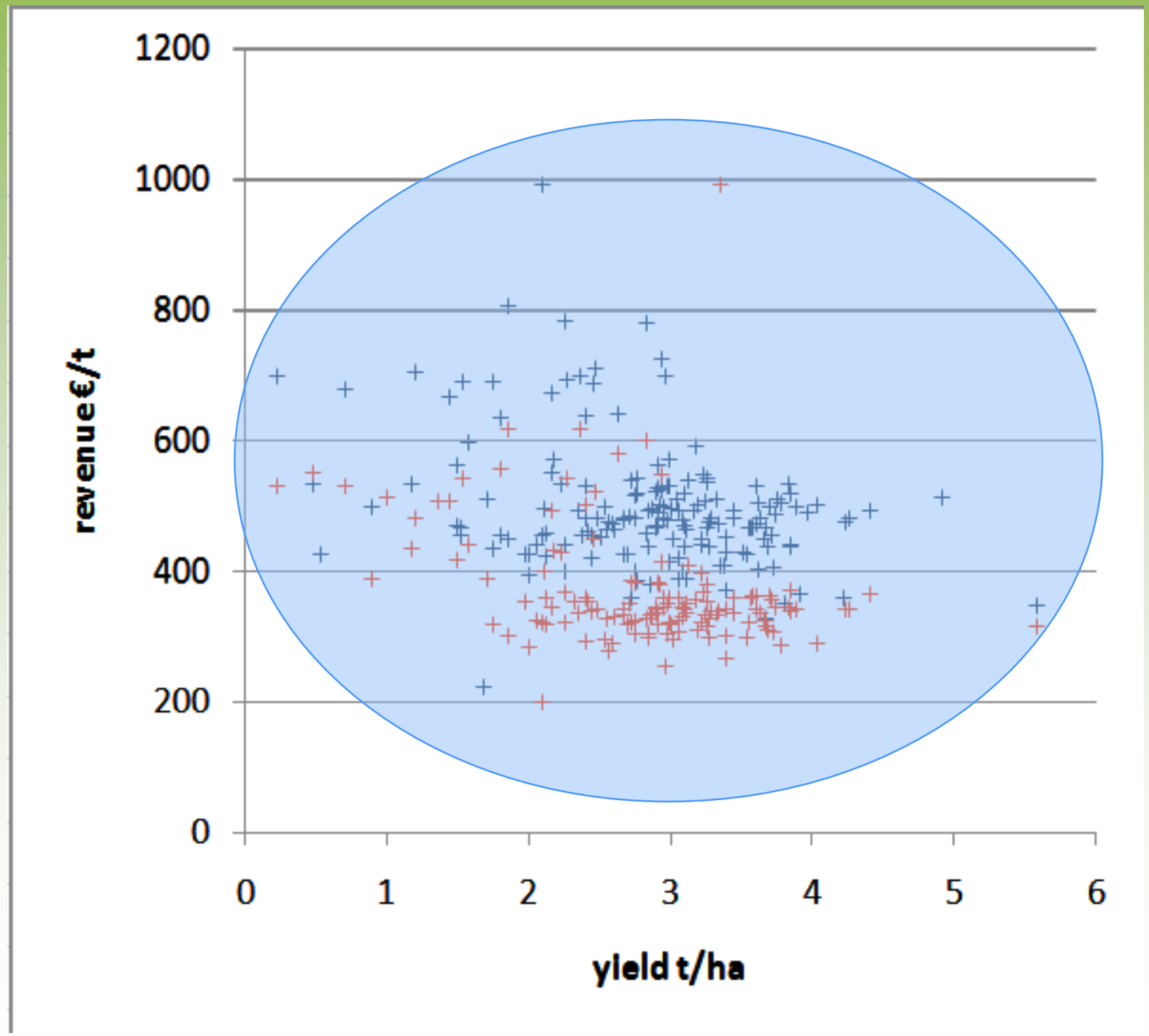


Source: own construction

discussion

- **heterogeneity has to be accounted for**
- **integrated model approaches contribute to our understanding**
- **accounting for management variants helps explain yield ranges**
- **in Austria: CC impact relatively minor compared to other factors (e.g. management)**

outlook:
yield & revenue variance



Source: FADN, LBG, BMLFUW, own calculations