Chair of Forestry Economics and Planning

Journal of Forest Economics, 2019, 34: 99–128

Uncertainty of Carbon Economy Using the Faustmann Model

Rasoul Yousefpour and Andrey L. D. Augustynczik*

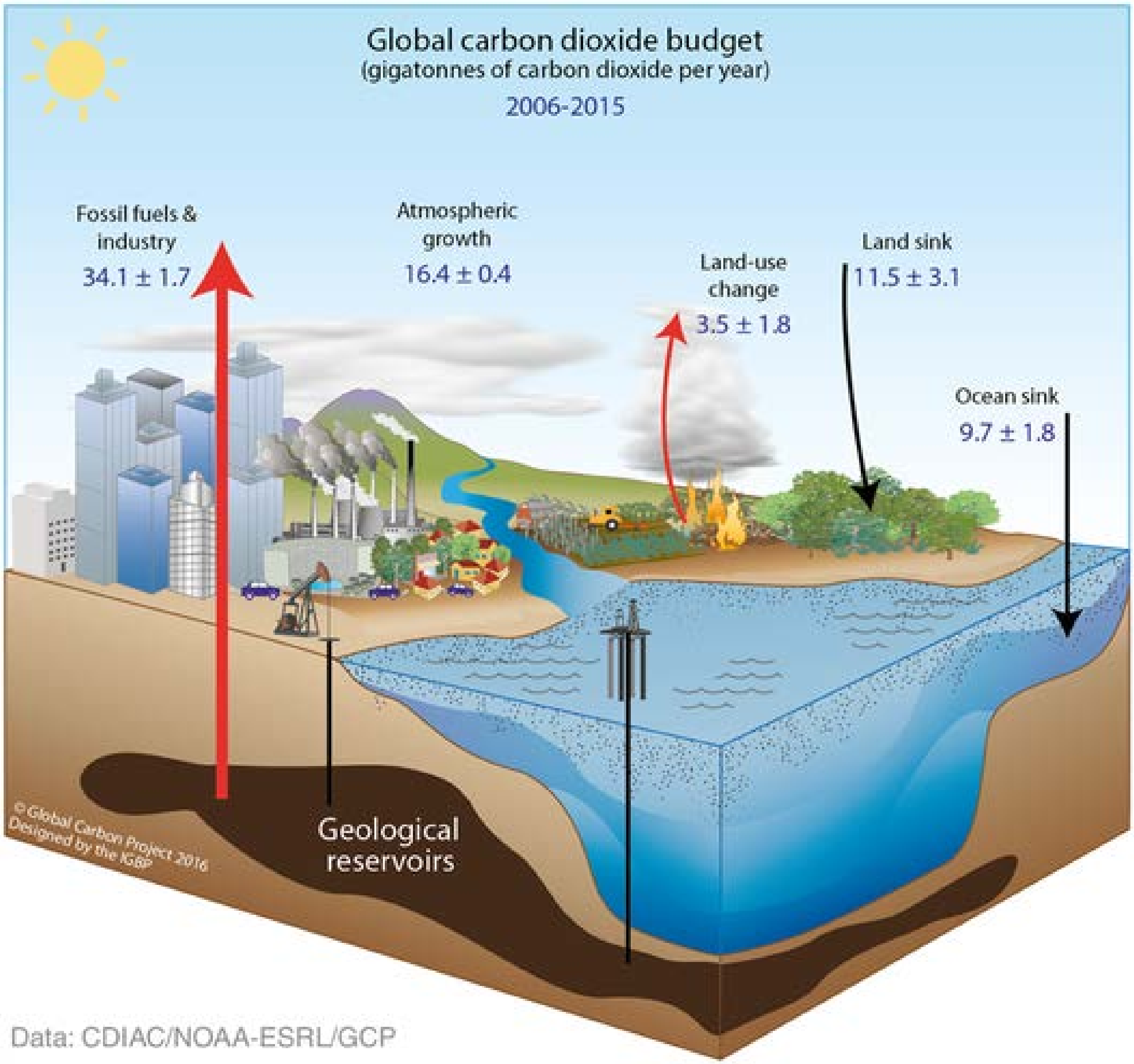
Chair of Forestry Economics and Forest Planning, University of Freiburg, Tennenbacherstr. 4, 79106 Freiburg, Germany; rasoul.yousefpour@ife.uni-freiburg.de

UNI FREIBURG

FORMASAM Final Meeting, PIK, Potsdam

4th March 2020

Fate of anthropogenic CO_2 emissions

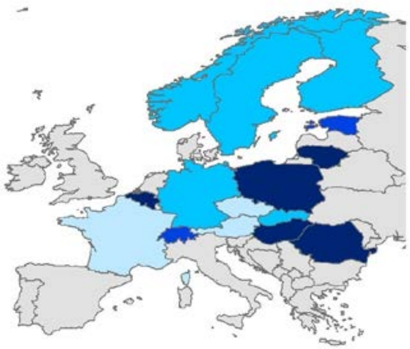


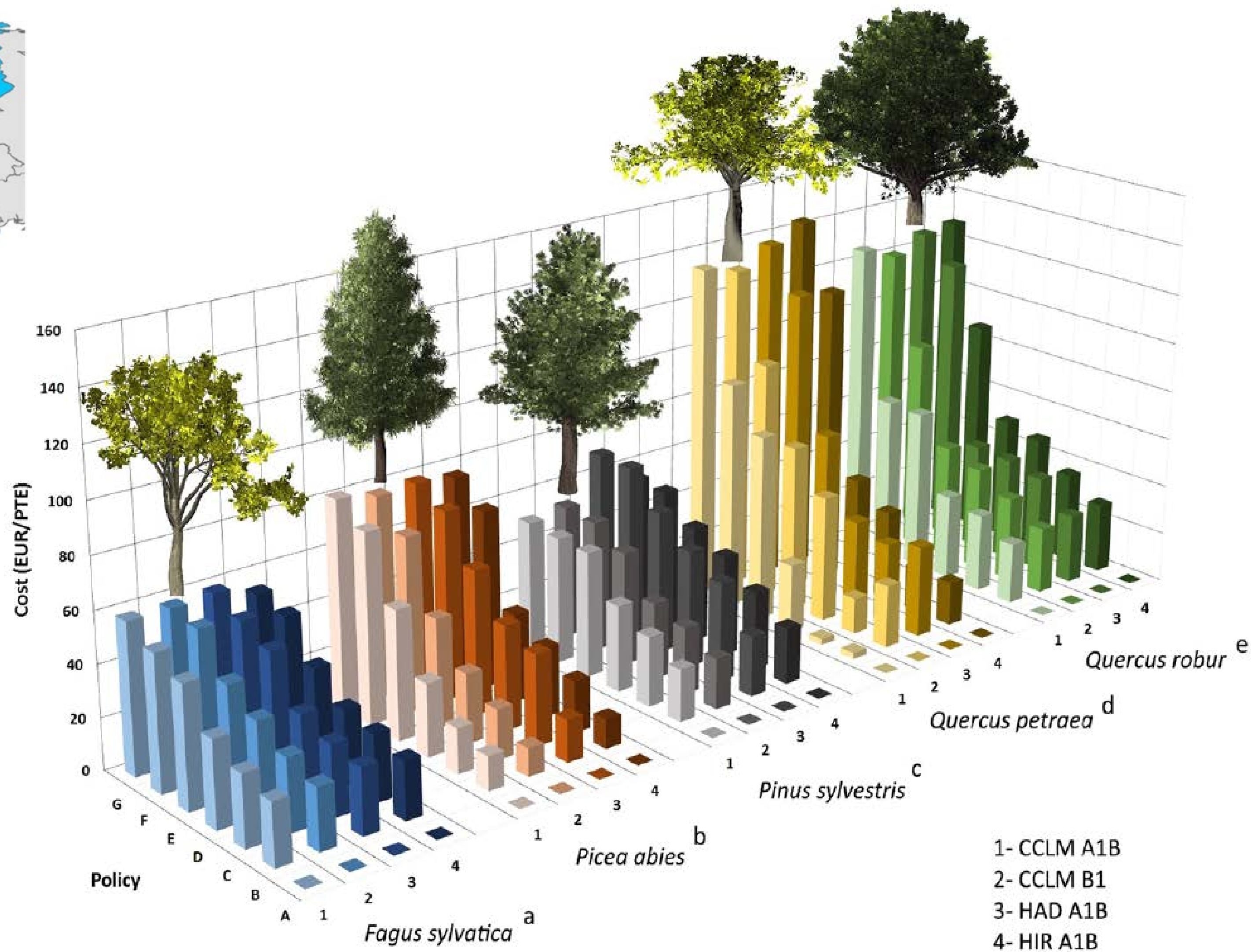
SCIENTIFIC REPORTS

Realizing Mitigation Efficiency of European Commercial Forests by Climate Smart Forestry

Chair of Forestry Economics and Planning

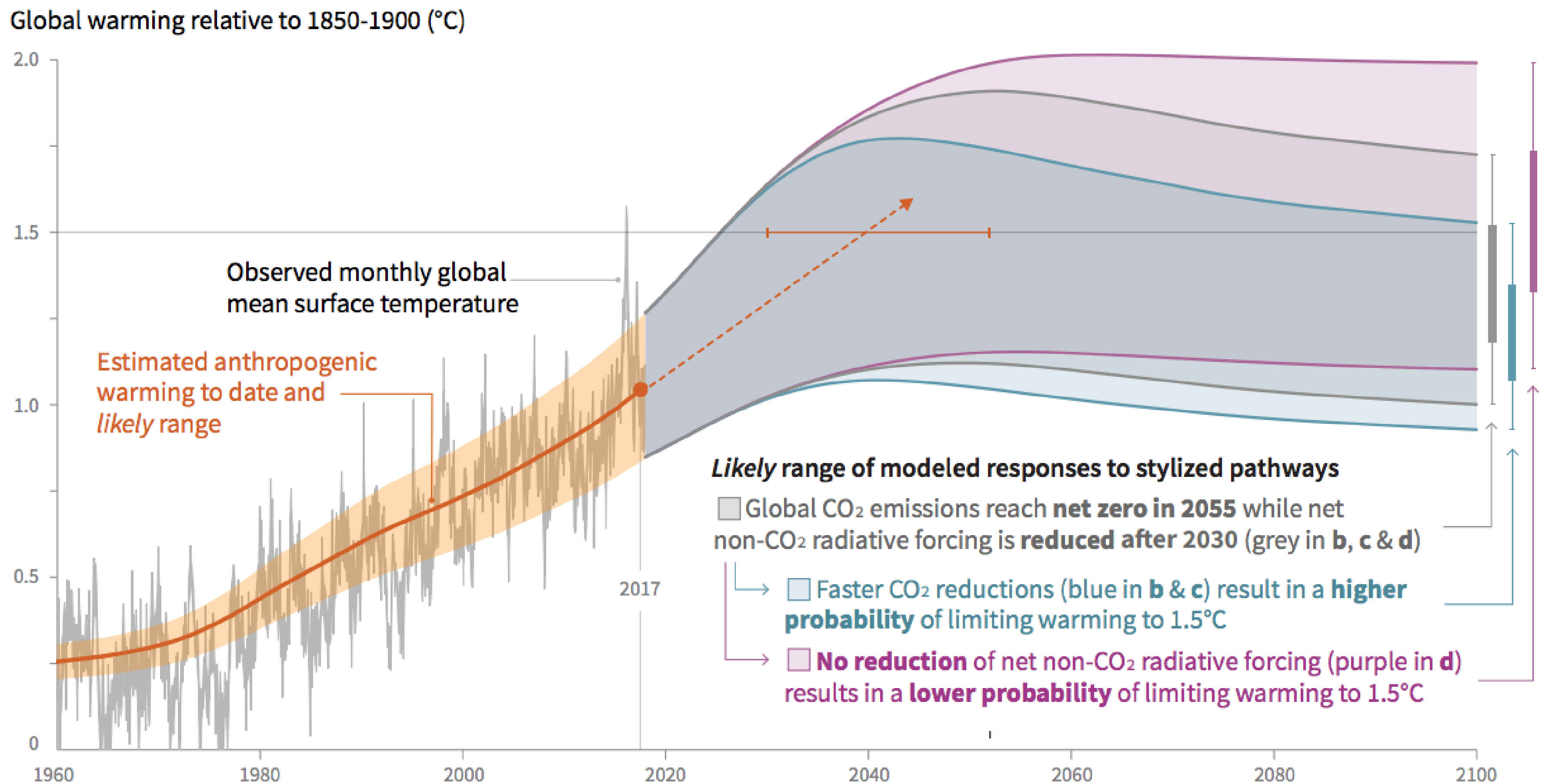
Rasoul Yousefpour[1], Andrey Lessa Derci Augustynczik[1], Christopher P. O. Reyer[2], Petra Lasch-Born[2], Felicitas Suckow[2] & Marc Hanewinkel[1]





Immediacy of mitigation

Chair of Forestry Economics and Planning



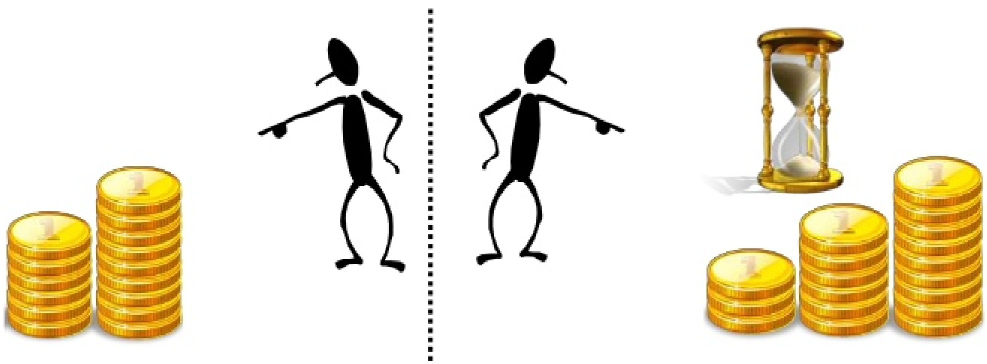
IPCC Chart shows observed monthly temperatures (black line), estimated human-caused warming (red), and idealized potential pathways to meeting 1.5C limit in 2100 (grey, blue and purple). All relative to 1850-1900.

UNI FREIBURG

Discounting

The tradeoff between now and later is called time discounting.

We trade money/sensation/experience today for money/sensation/experience later.



Question: Which is worth more?

$10,000 to be received with certainty one year from today, or:

$10,000 received right now?

$9,500 received now?,

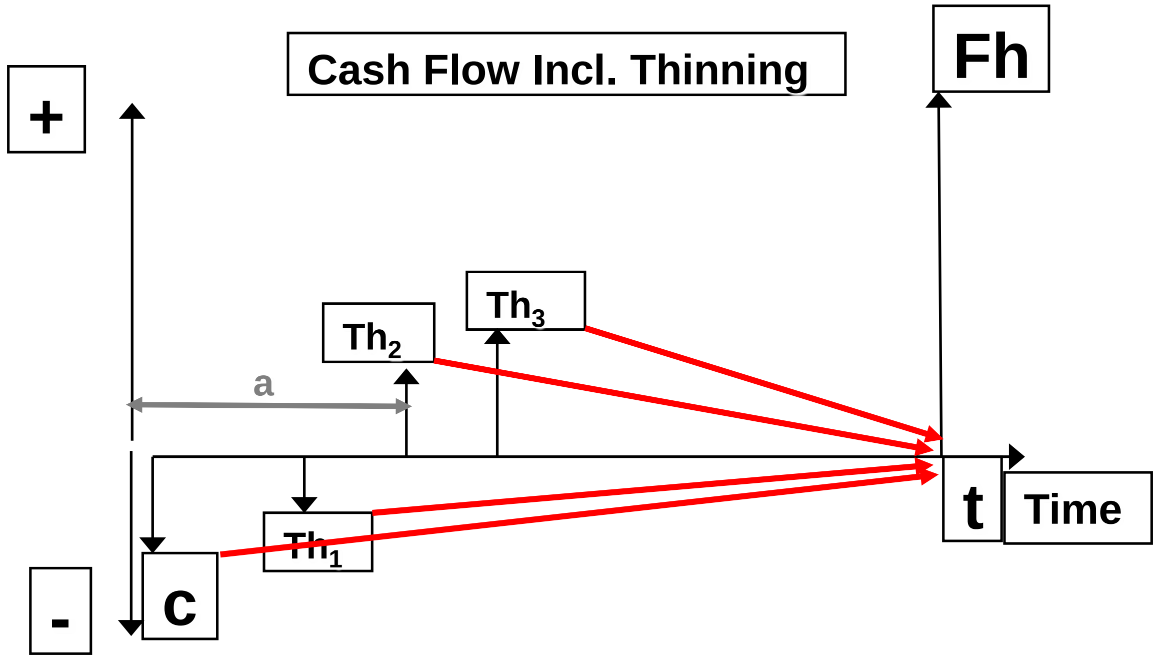
$8,000 received now?

8,000 = 10,000 / (1+0,25)^1

or

10,000 = 8,000 * (1,25^1)

NPV, LEV



Th1-Th3 = Thinning
FH= Final harvest
t = Rotation period

$$NPV = Fh_t + \sum_{a=1}^{t} Th_a (1+i)^{t-a} - c(1+i)^t$$

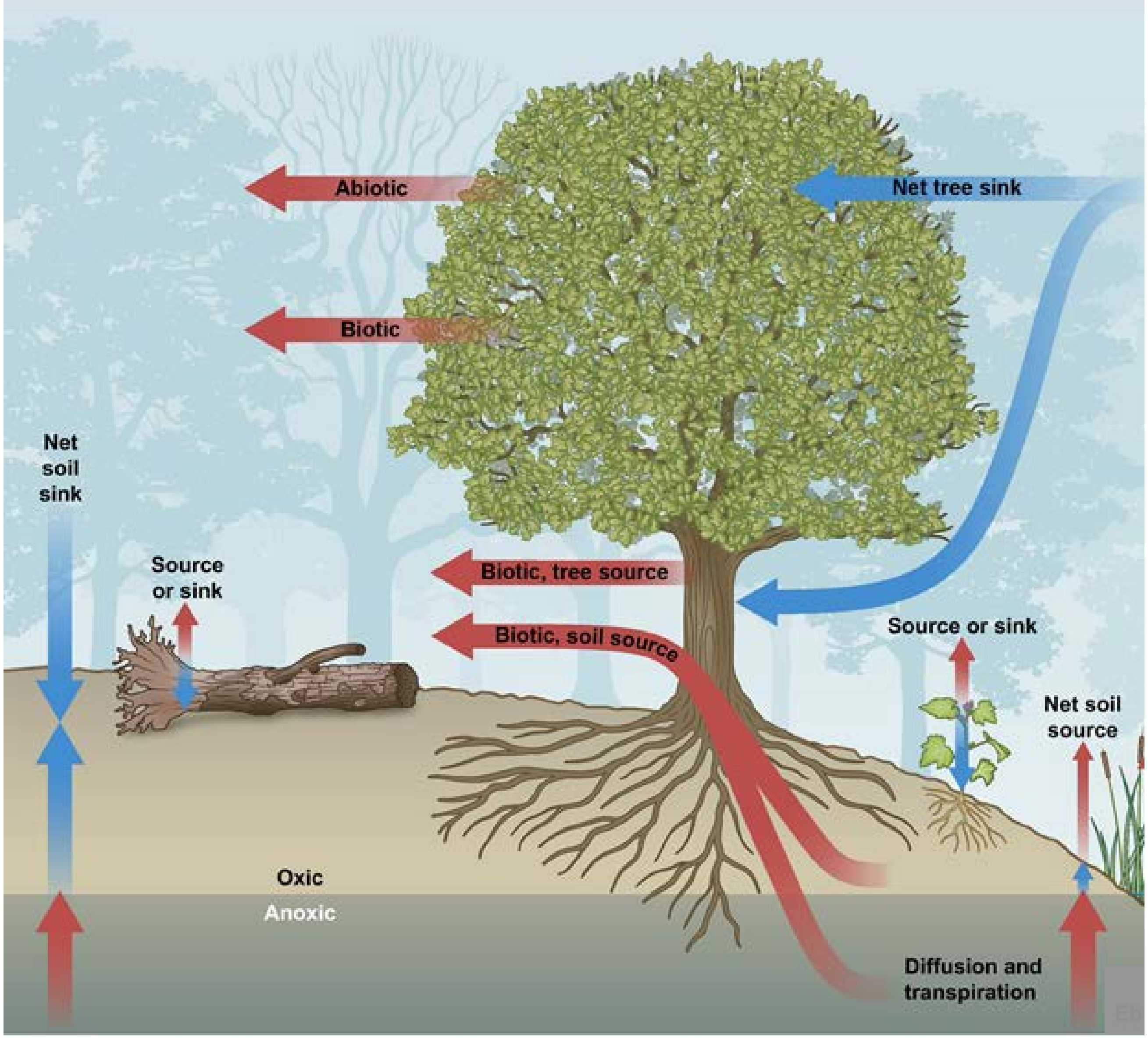
Infinite series of Identical

Even-aged Rotations

$$\text{LEV} = \frac{\text{NPV}(1+i)^r}{(1+i)^r - 1}$$

Discount Carbon → PTE (Present Tonne Equivalant)

Forest Carbon Cycle Uncertainty



Forest Carbon Uncertainty & Decisions

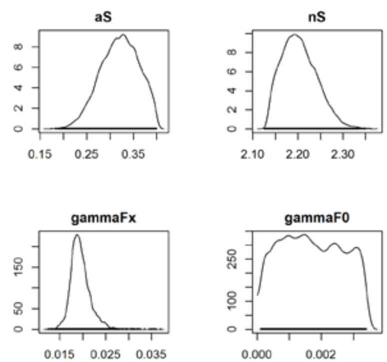
Chair of Forestry Economics and Planning

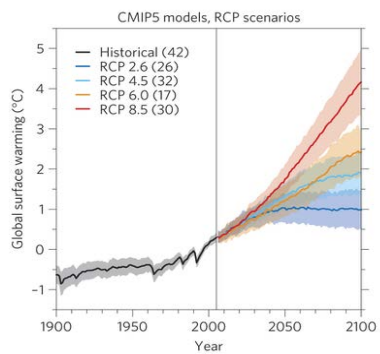
Model uncertainty

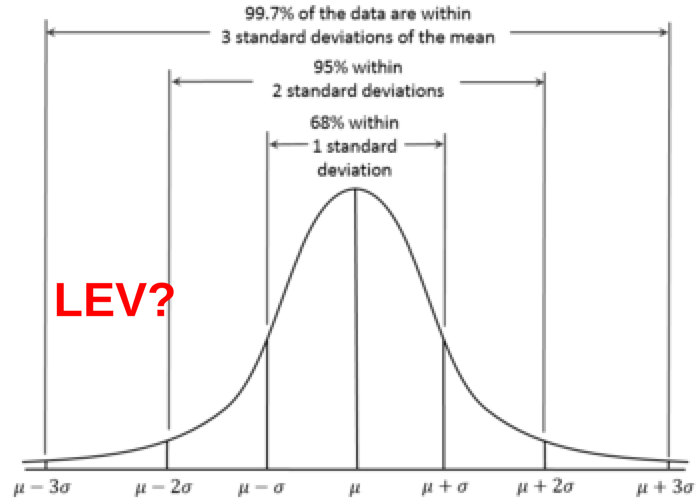
- Process-based models
- Higher parameter uncertainty
- Propagates to predictions

Climate uncertainty

- Temperature
- Precipitation
- CO2 concentration







UNI FREIBURG

Protocol

Chair of Forestry Economics and Planning

Climate Scenarios:
Realisation of no, low, and extreme scenarios RCP2.6, RCP4.5, RCP6.0 and RCP8.5 by global climate models HadGEM2-ES, IPSL-CM5A-LR and NorESM1-M, downscaled by the regional climate model ISIMIP

Deterministic versus Stochastic Modelling:
Model run with(out)uncertainty propagation

Weighting Carbon versus LEV:
Equal, Favoring, Discouraging

Management Options:
Increase/Decrease BAU Harvest Rate for *Fagus Sylvatica*

Discount LEV (Land Expectation Value):
Fixed 2%

Discount Carbon (Present Tonne Equivalant carbon):
Fixed 2%, No time preference

UNI FREIBURG

3PG

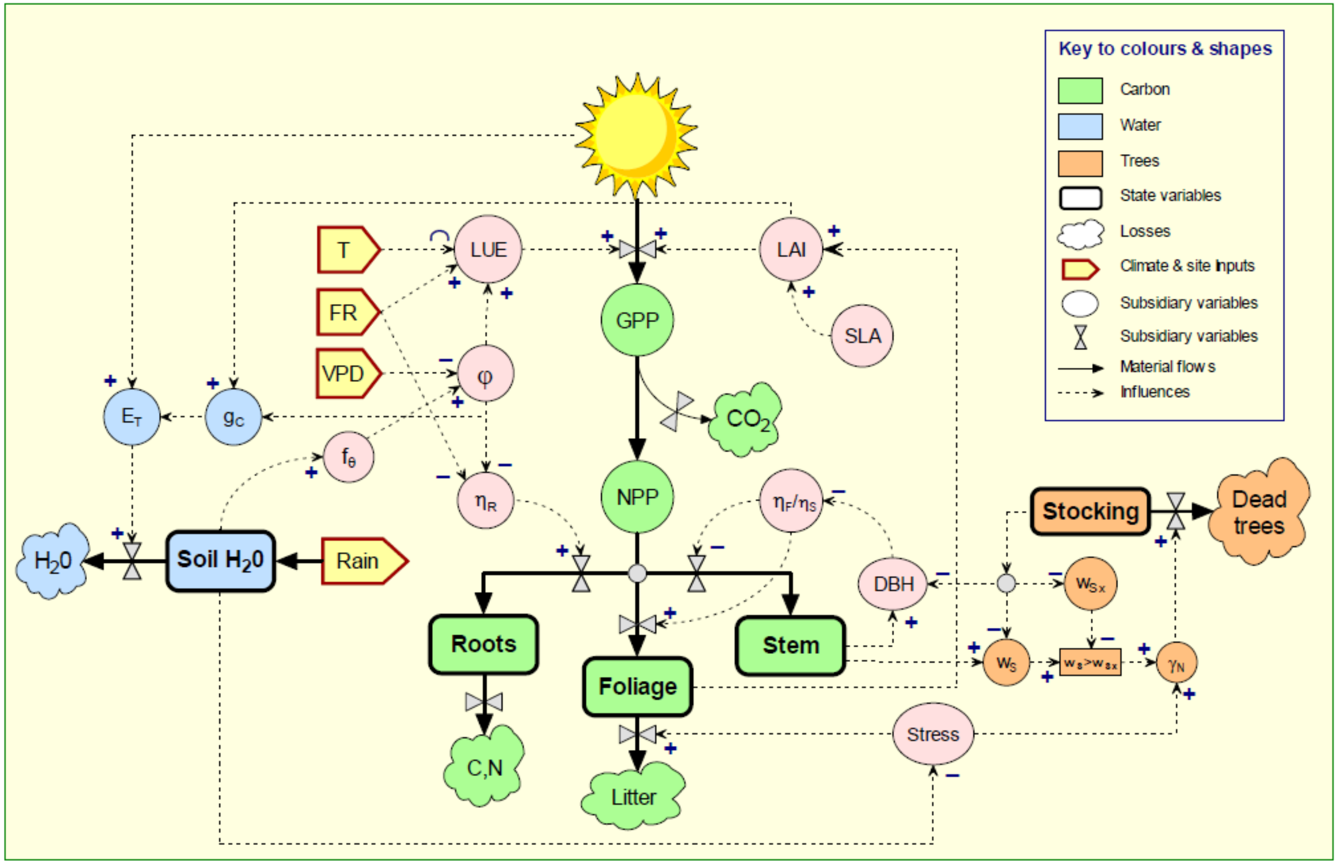


Figure 1: Components of 3-PG (Physiological Principles Predicting Growth).
Source: http://3pg.sites.olt.ubc.ca/files/2014/04/What-is-3PG.pdf.

Minimum Input

- **Climate data:** Temperature, solar radiation, VPD, precipitation
- **Site properties:** Fertility (0 – 1), soil texture
- **Management:** Initial tree biomass & stocking, thinning (time, intensity, type) and if applied: fertilization & irrigation

Modelling and Optimization Approach

Chair of Forestry Economics and Planning

Management **Options**:

1- Forest Conservation (**No management**)

2- Business as usual (**BAU**)

3- **Intensified** forest wood utilization

4- **Reduced** forest wood utilization

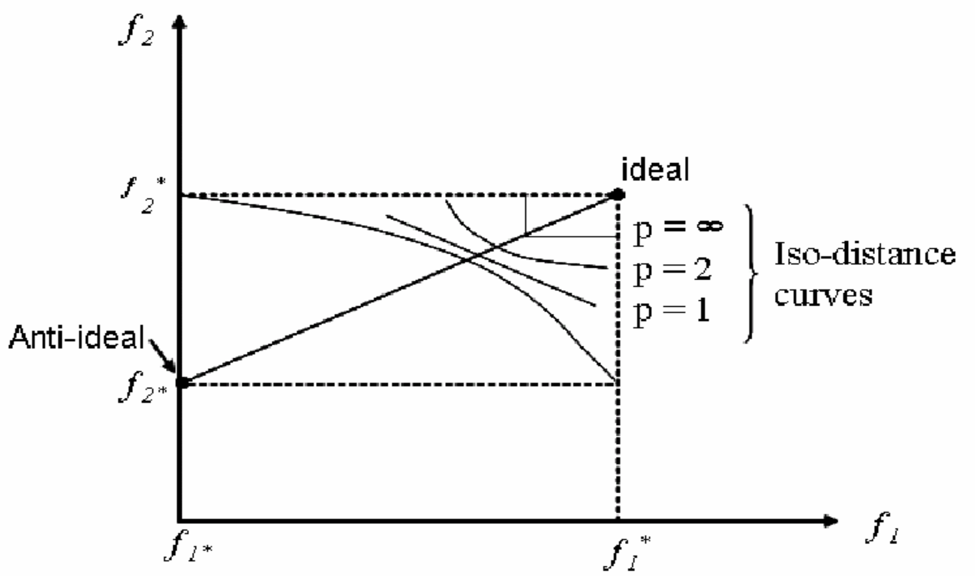
5 options of N/ha x 5 options of % of biomass removal => 25 regimes

Weighting scheme for LEV and Carbon:

Scheme	Carbon weight	LEV weight
1	1	0.1
2	0.9	0.2
3	0.8	0.3
4	0.7	0.4
5	0.6	0.5
6	0.5	0.6
7	0.4	0.7
8	0.3	0.8
9	0.2	0.9
10	0.1	1

Compromise Programming

Chair of Forestry Economics and Planning



w1: normalized weight for LEV

w2: normalized weight for Carbon

CC: set of climate change scenarios

i: management regime

1) Deterministic Optimum Case Eucliden norm

$$\text{Min } Z = \sum_{j \in CC} \sqrt{w_1 LEV_{j-}^2 + w_2 CAR_{j-}^2}$$

2) **Deterministic Robust** Case (L1 norm)

$$Min\, Z = \sqrt{w_1 0.5(RLEV_{\min} + RLEV_{\max})^2 + w_2 0.5(RCAR_{\min} + RCAR_{\max})^2}$$

3) **Uncertain Robust** Case Euclidean norm

$$Min\, Z = \sqrt{w_1\, VaRlev_-^2 + w_2\, VaRcar_-^2}$$

UNI FREIBURG

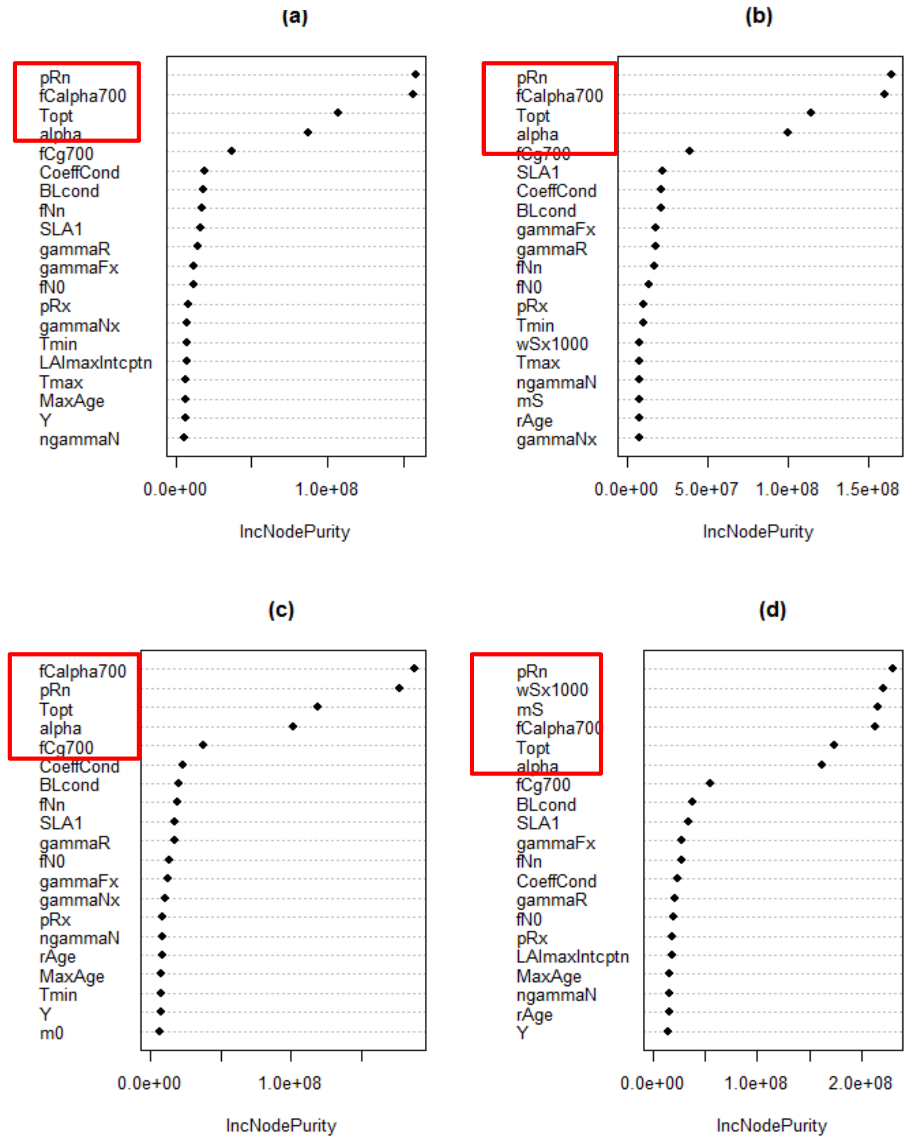
Sources of Model Uncertainty (random forest technique)

Chair of Forestry Economics and Planning

- Parameters related to CO2 fertilization
- Parameters related to absorbed PAR
- Direct impact on growth rates and wood production
- Focus for future data collection in order to produce narrower ranges
- a)-c): Thinning alternatives and d) no thinning (just mortality)

IncNodePurity (Incident Node Purity):
A Gini index for showing parameter importance in random forest analysis

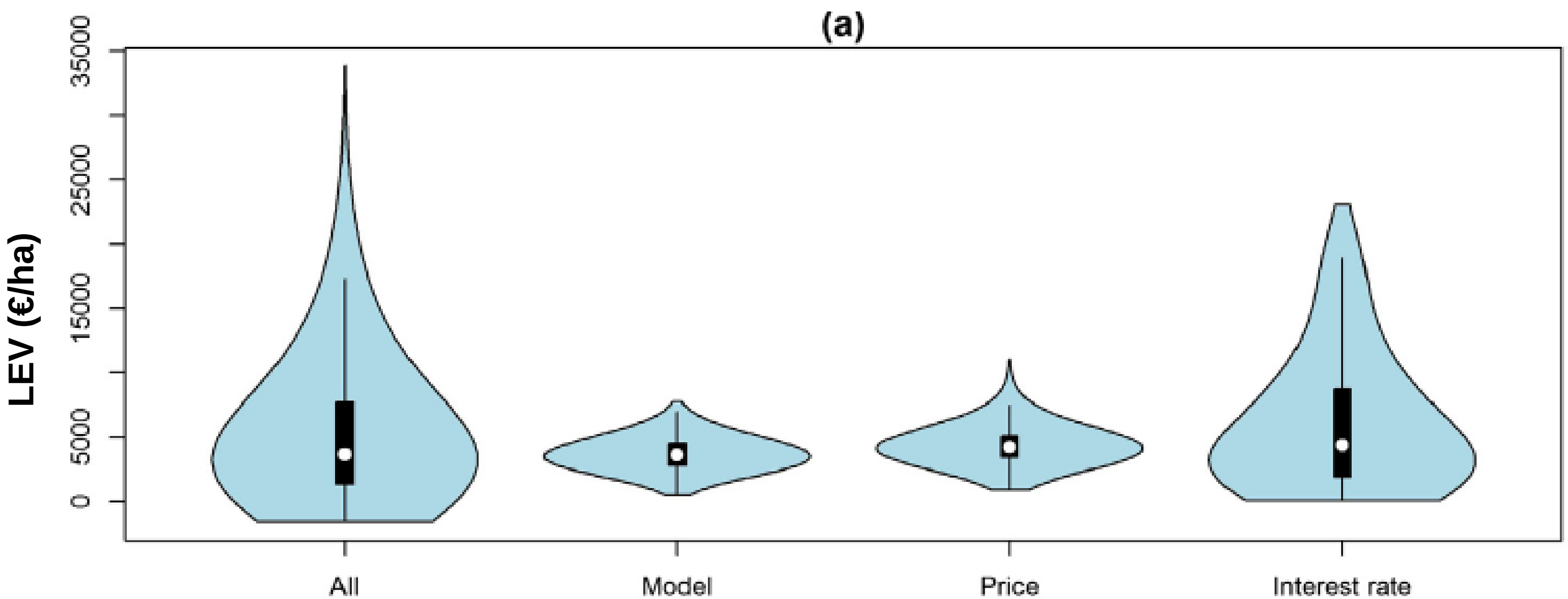
↑ Higher IncNodePurity = ↑ Impacts on LEV



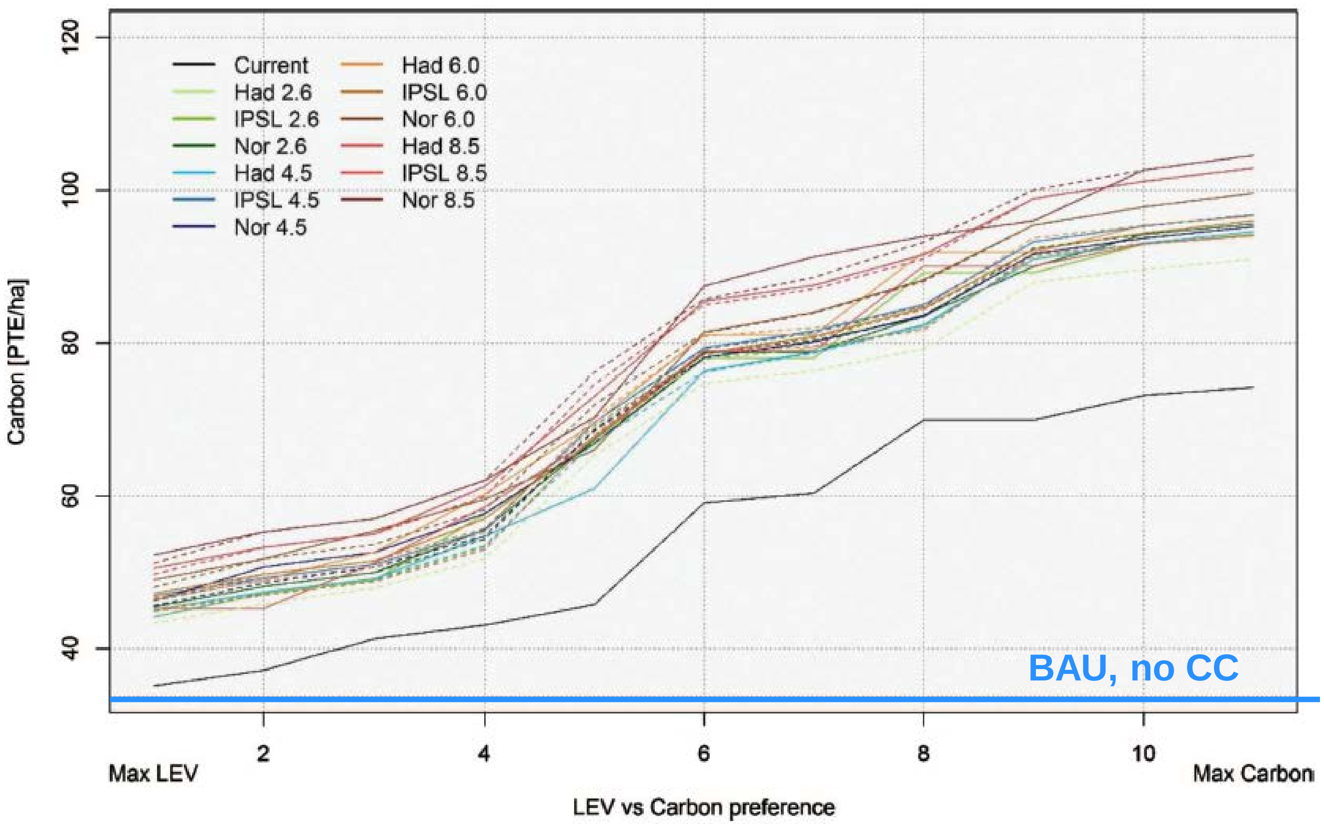
pRn = max. carbon allocation to roots
fCalpha700 = CO2 fertilization effect
Topt = optimal growth temperature
Alpha = canopy conductance
mS = stem mortality rate
wS1000 = stem mass of mean tree

Productivity of *Fagus sylvatica* under climate change – A Bayesian analysis of risk and uncertainty using the model 3-PG

Andrey L.D. Augustynczik [a,*], Florian Hartig [b,c], Francesco Minunno [d], Hans-Peter Kahle [e], Daniela Diaconu [e], Marc Hanewinkel [a], Rasoul Yousefpour [a]



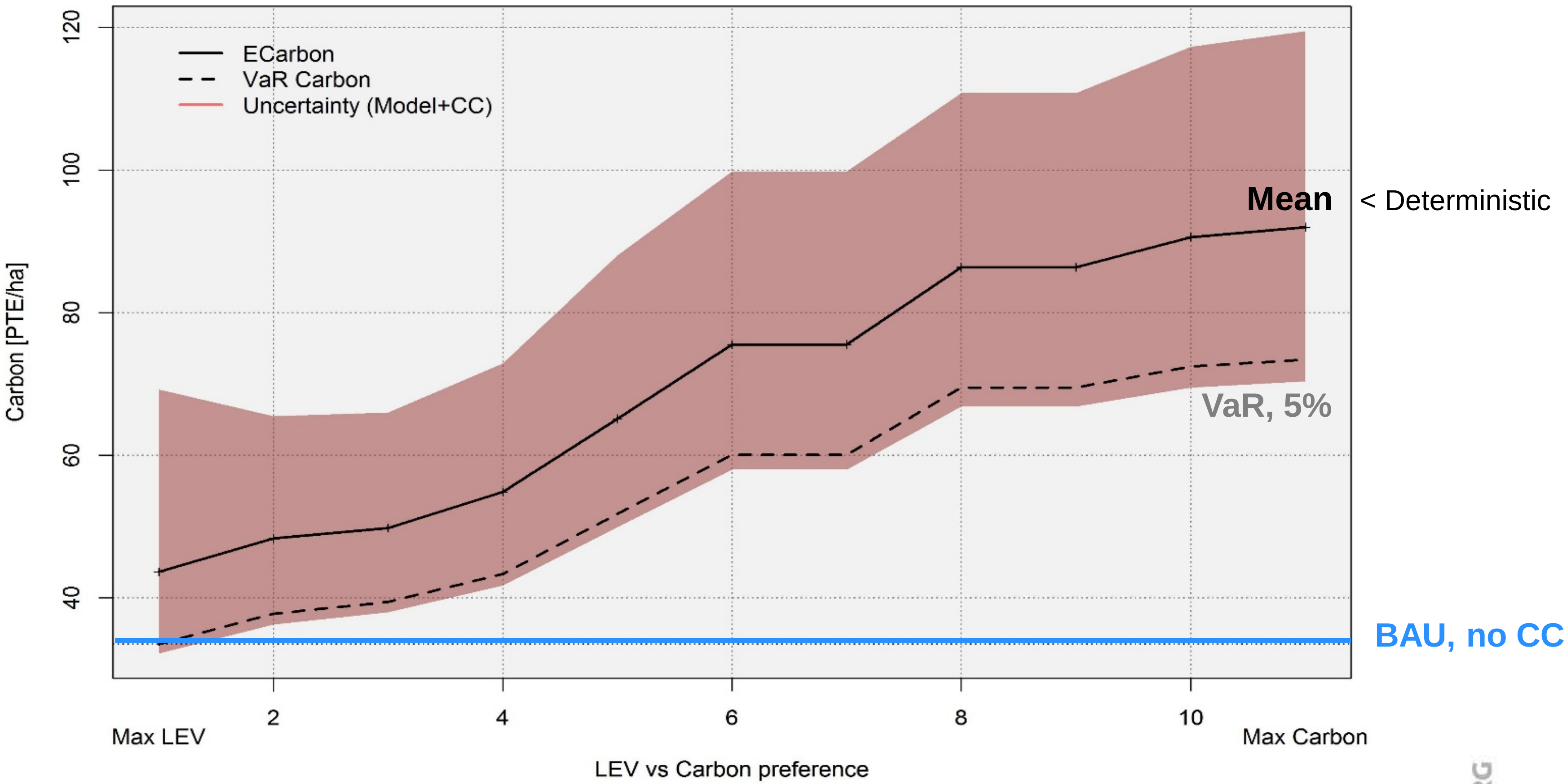
Deterministic (robust) case



BAU is not optimal for mitigation

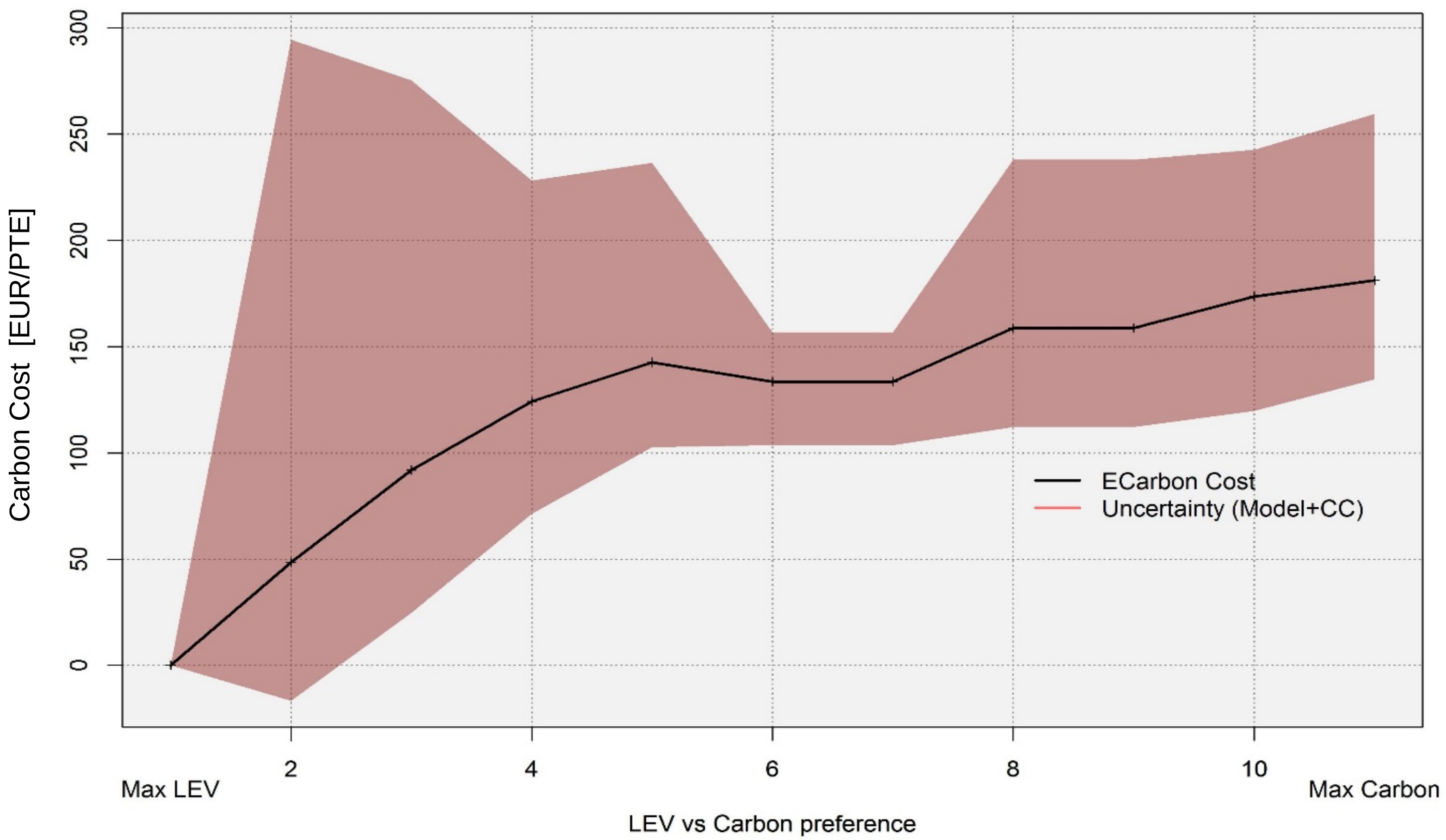
Figure 6: Carbon sequestration for the deterministic and robust towards climate optimal solutions. The solid lines represent the deterministic solution and the dashed lines show the robust solution. The dotted horizontal line shows the result for the BAU management and current climate.

Carbon (PTE)


ECarbon
VaR Carbon
Uncertainty (Model+CC)
120
100
80
60
40
Carbon [PTE/ha]
2
4
6
8
10
Max LEV
Max Carbon
LEV vs Carbon preference
Mean
< Deterministic
VaR, 5%
BAU, no CC

Carbon Cost (EUR/PTE)

Chair of Forestry
Economics and Planning



UNI FREIBURG

Concluding Lessons

Chair of Forestry Economics and Planning

- **Process-based models** are favored to integrate carbon cycle analysis and economy but s. t. uncertaity
- (No)Discounting (0 vs. 2%) has been found to be decisive regarding **carbon sequestration level and cost**
- Current **carbon trade price** is NOT sufficient to encourage commercial mitigation in forestry
- Quantification of **forest carbon budget** is uncertain and needs transparent guidelines to realize an effective carbon policy.

UNI FREIBURG

Thank you for attention!

Rasoul Yousefpour & Andrey L. D. Augustynczik
@ Chair of Forestry Economics and Forest Planning
Tennenbacher Straße 4, D-79106 Freiburg, Germany

Phone: +49-(0)761-203-3688
E-Mail: rasoul.yousefpour@ife.uni-freiburg.de

Novel Research Concept (I)
Insurance Value of Forest Ecosystems

Natural Insurance: Sylviculture

FOREST OWNER

Natural Insurance

Risk Premium

HOUSE OWNER

Financial Insurance

1- Risk premium for natural insurance is LOWER than risk premium for financial insurance?

2- Find the best combination of natural and financial insurance to deal with risks

WSL SLF UNI FREIBURG

Chair of Forestry Economics and Planning

Nancy, France, July 1-3, 2020

IUFRO Division 4.04.07 Risk analysis Conference

International Union of Forest Research Organizations

IUFRO

Interconnecting Forests, Science and People

Socio-Ecological Conflicts in Forest Management: Risk of (Not) Adapting ?

Abstracts submission deadline: March 31, 2020

AgroParisTech -14 rue Girardet - Nancy, France

https://workshop.inrae.fr/iufro-risk-analysis-nancy/

INRAE · BETA Bureau d'économie théorique et appliquée · arbre · AgroParisTech · UNI FREIBURG

UNI FREIBURG