The effect of species mixing on tree and stand growth. Review and perspectives

Hans Pretzsch

Chair for Forest Growth and Yield Science

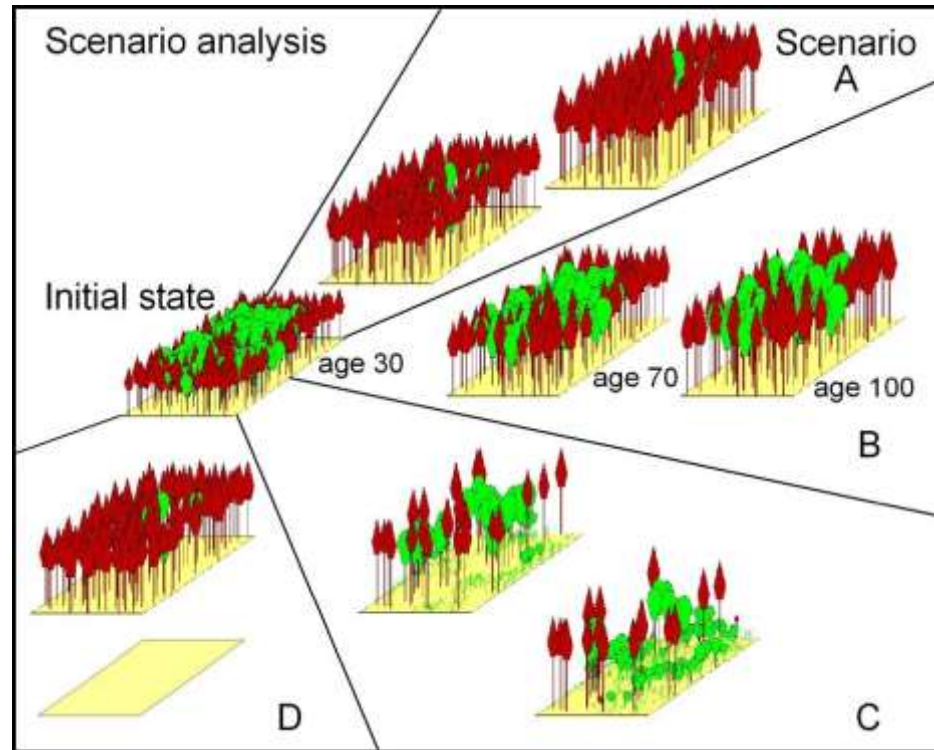Technical University of Munich

http://www.wwk.forst.wzw.tum.de/info/presentations/

1 Need for silvicultural guidelines and models for mixed-species stands

2 Key mixing effects on tree and stand dynamics

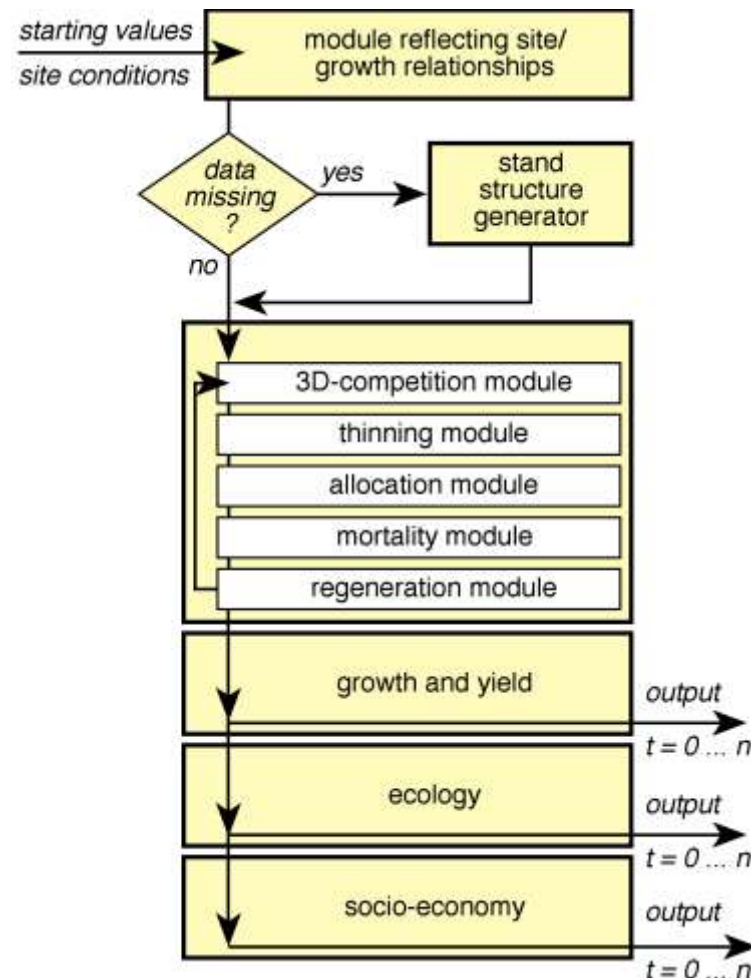3 Measures for silvicultural regulation of mixed-species stands

TUM

Guidelines for silvicultural regulation of mixed-species stand can bring the mixing idea onto the ground
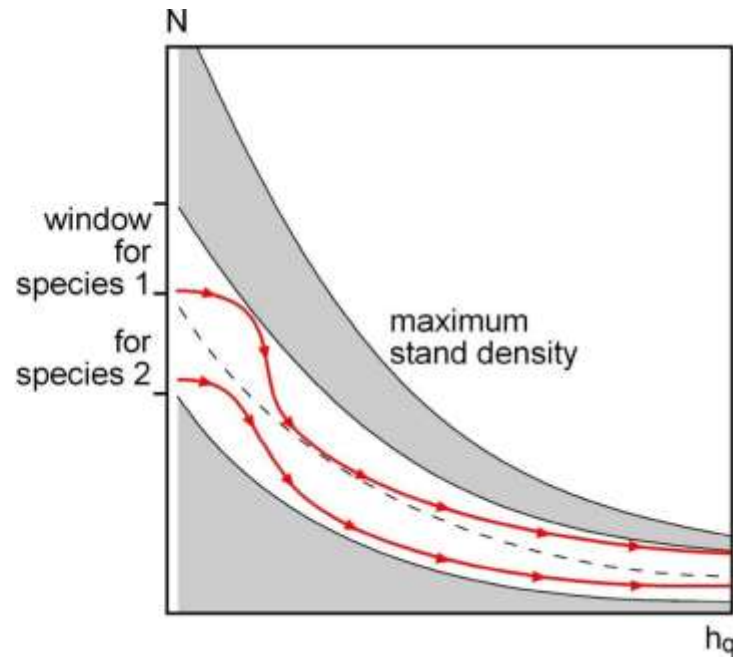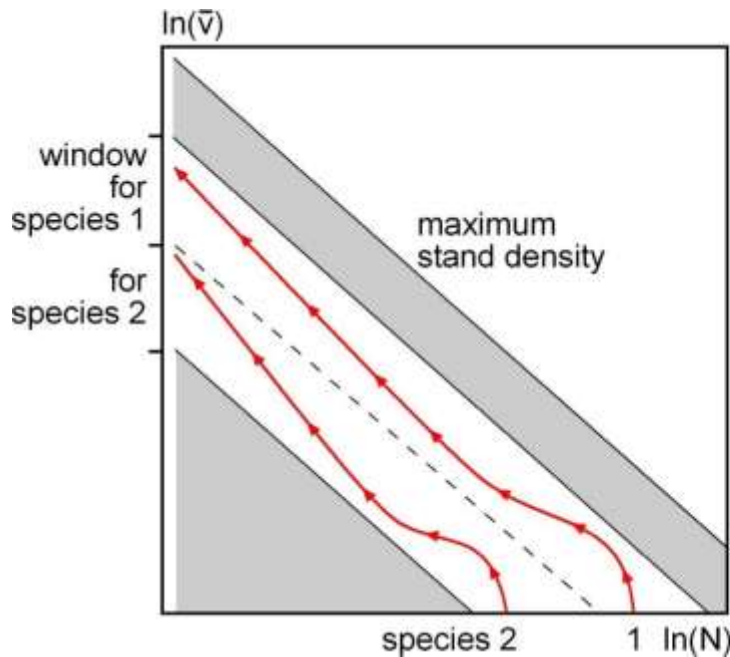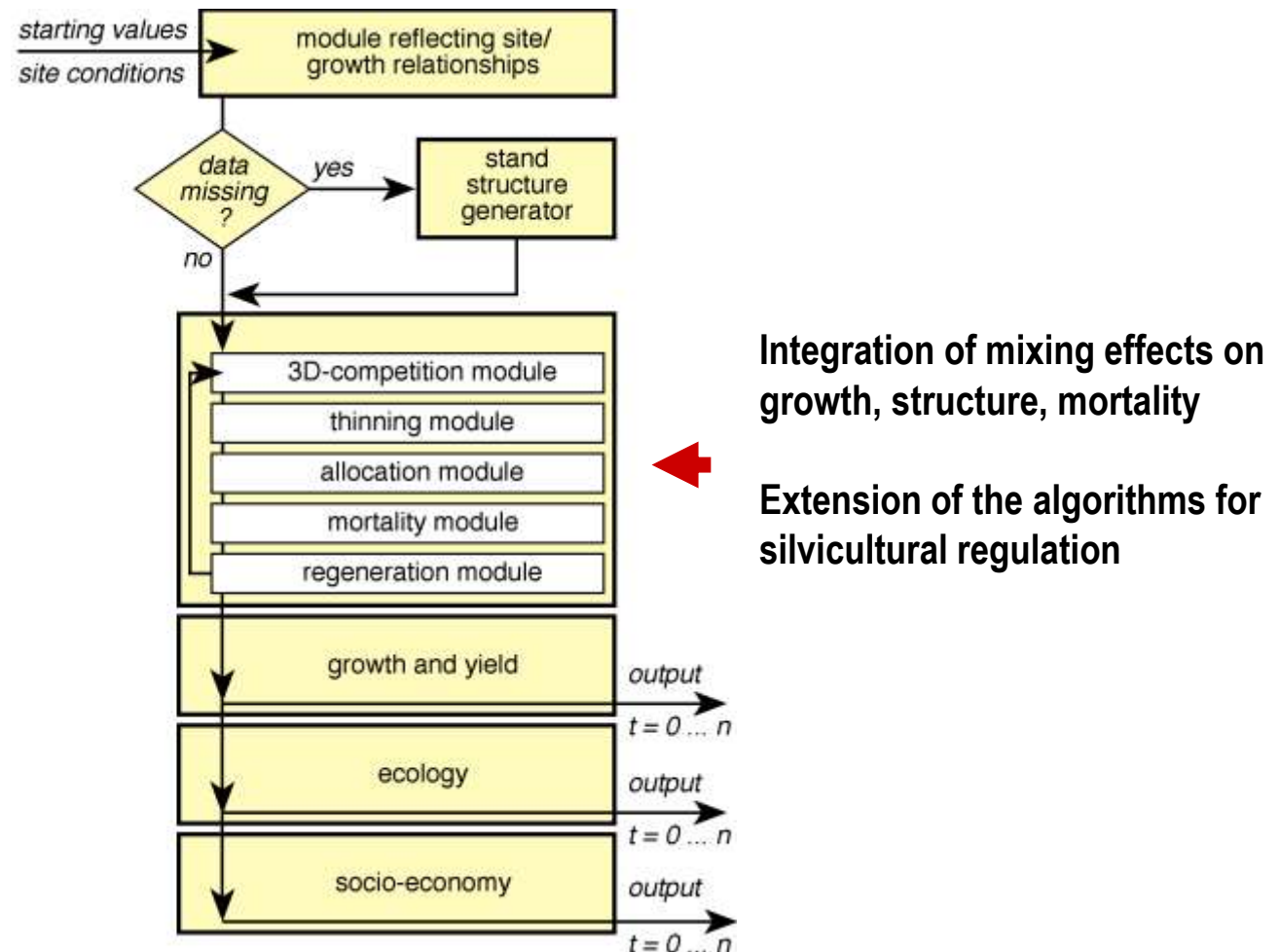
Silvicultural guidelines require models and scenario analyses of silvicultural options

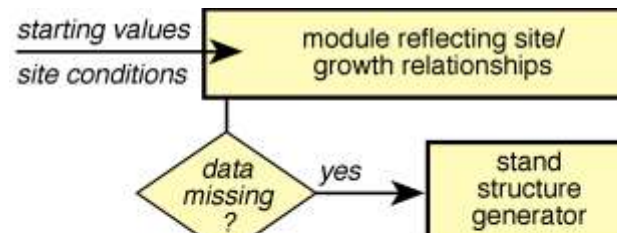# SILVA 3.0 as example of a spatially explicit individual tree model for pure and mixed stands

Pretzsch, H., Biber, P. und Dursky, J., 2002: The single tree based stand simulator SILVA. Construction, application and evaluation, Forest Ecology and Management, 162: 3-21

SILVA 3.0 as example of a spatially explicit individual tree model for pure and mixed stands

Integration of mixing effects on growth, structure, mortality

Extension of the algorithms for silvicultural regulation

Pretzsch, H., Biber, P. und Dursky, J., 2002: The single tree based stand simulator SILVA. Construction, application and evaluation, Forest Ecology and Management, 162: 3-21

SILVA 3.0 as example of a spatially explicit individual tree model for pure and mixed stands

starting values
site conditions
→ module reflecting site/growth relationships
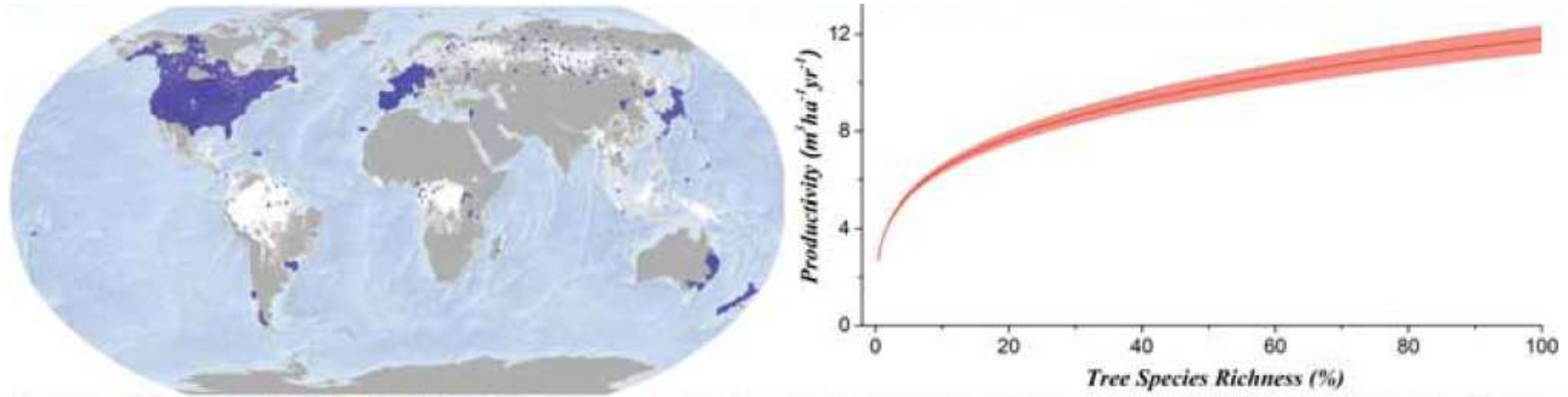
data missing ? — yes → stand structure generator

Summary 1:
- For bringing the mixed-species stand idea to the ground we need silvicultural guidelines, based on models and scenario analyses
- So far, scattered mosaic pieces of knowledge about mixed stands need integration to a picture of the whole
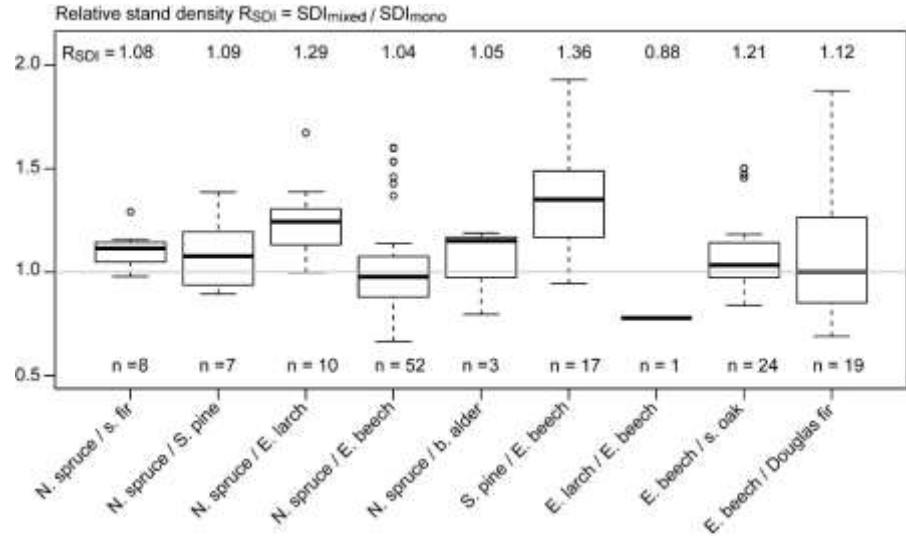- Mixed stand models require rules for silvicultural regulation

ecology — output — $t = 0 \dots n$

socio-economy — output — $t = 0 \dots n$

$t = 0 \dots n$

Pretzsch, H., Biber, P. und Dursky, J., 2002: The single tree based stand simulator SILVA. Construction, application and evaluation, Forest Ecology and Management, 162: 3-21
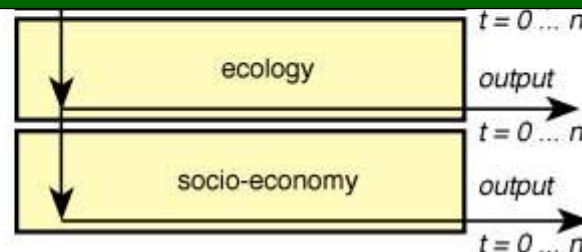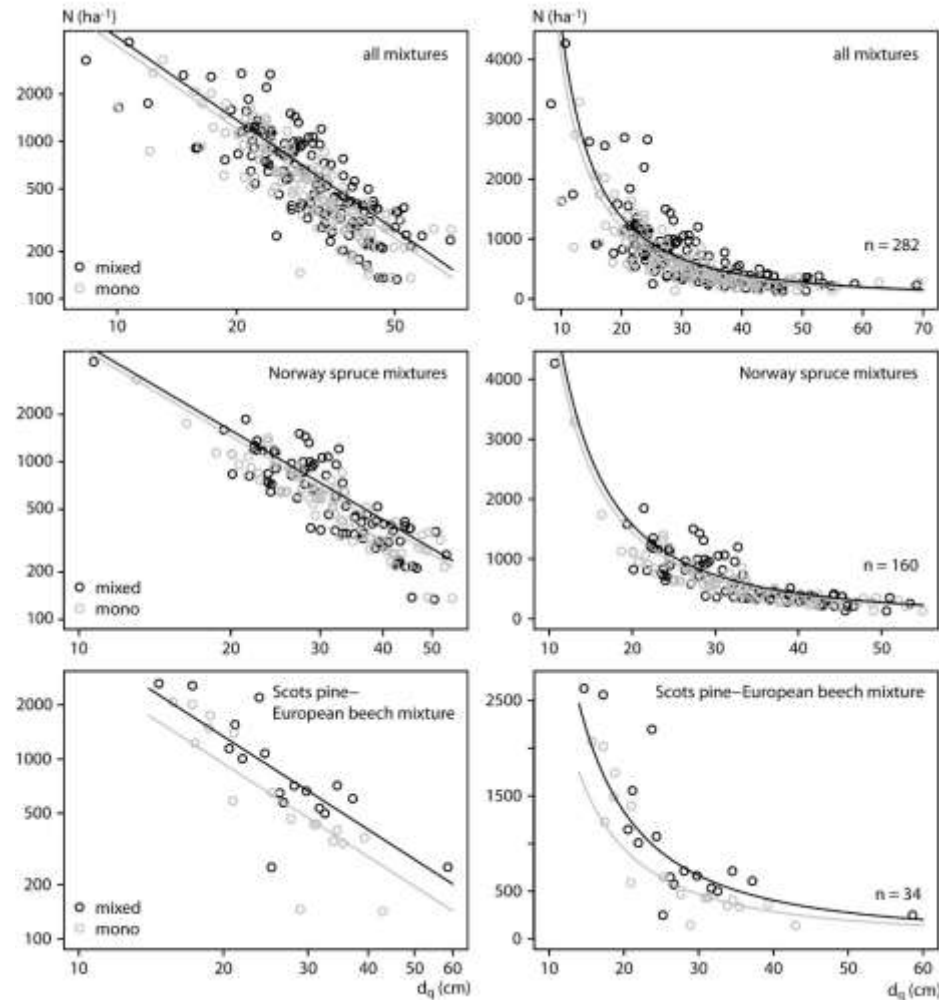
Mixing effects on productivity. Inventory data worldwide and experiments in Central Europe
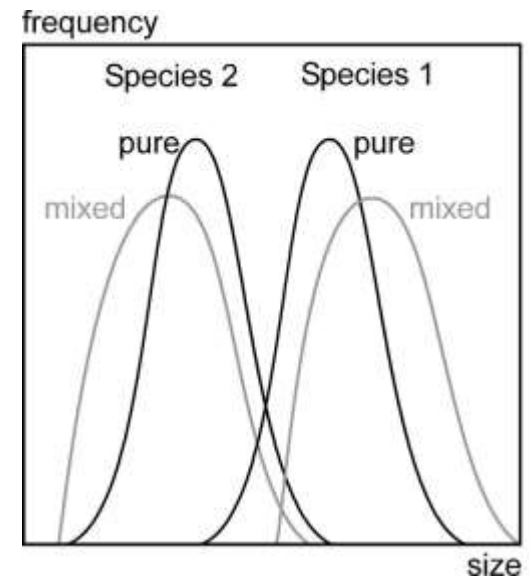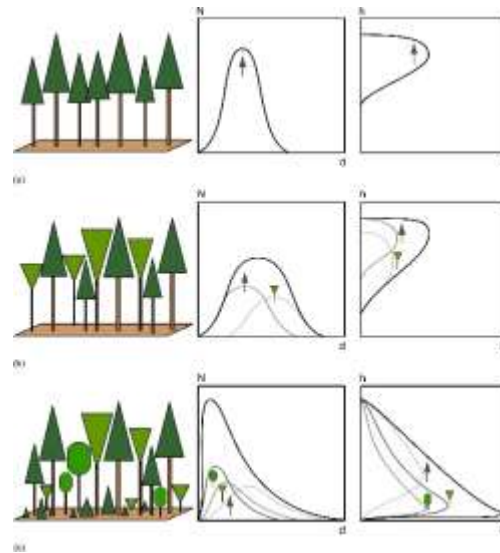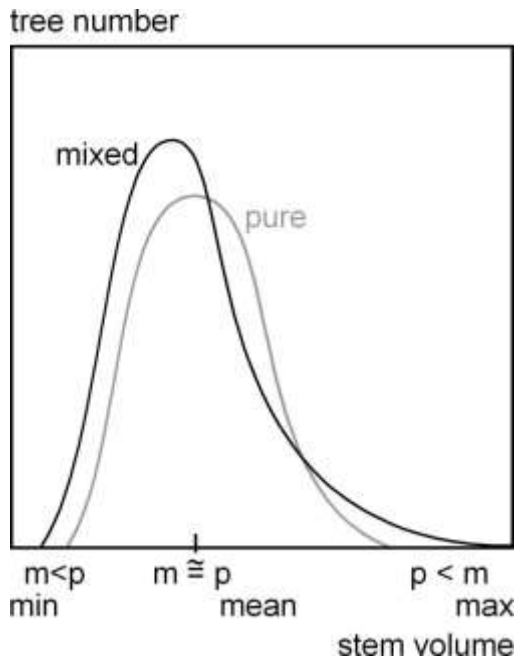

Liang, J. et al. (2016) Positive Biodiversity-Productivity Relationship Predominant in Global Forests, Science 354(6309):aaf8957

Species combination	N. sp/ E. be	S. pi/ E. be	s. oak/ E. be	E. be/ D-fir	S. pi/ N. sp	E. la/ N. sp	N. sp/ s. fir	mean
overyielding (± SE) in %	21 (± 3)	30 (± 9)	20 (± 3)	11 (± 8)	21 (± 11)	25 (± 6)	13 (± 6)	
corr. factor	1.10	1.20	1.10	1.10	1.20	1.20	1.10	1.10

Pretzsch, Forrester, Bauhus (2017) Mixed-species forests. Ecology and management, Springer, Berlin, 653 p

Effect of tree species mixing on stand density represented by self-thinning line and SDI

Wider size range, stronger right-skewness in mixed stands; more vertical heterogeneity, often species 1 ahead, species 2 behind

Pretzsch, H., Schütze, G. (2014) Size-structure dynamics of mixed versus pure forest stands, Forest Systems, 23(3):560-572.
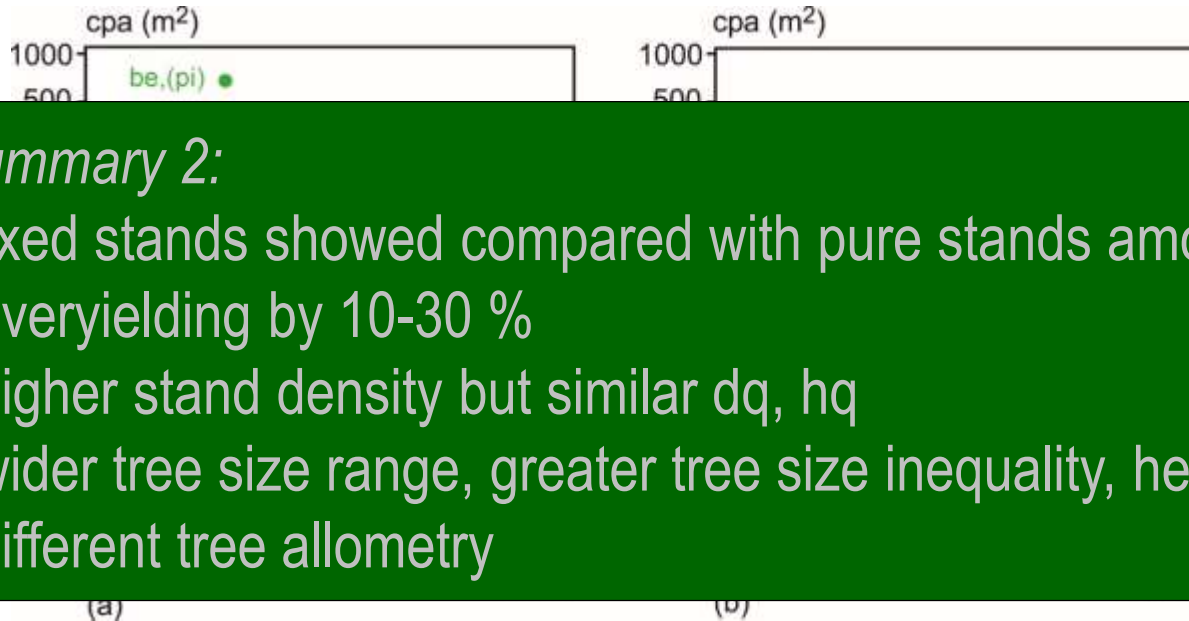
Allometry between crown projection area and stem diameter of European beech when growing in mono-specific versus mixed stands
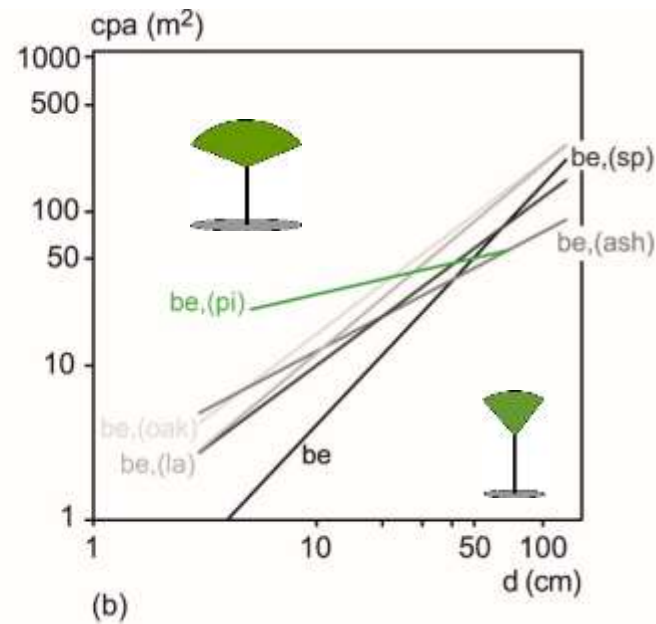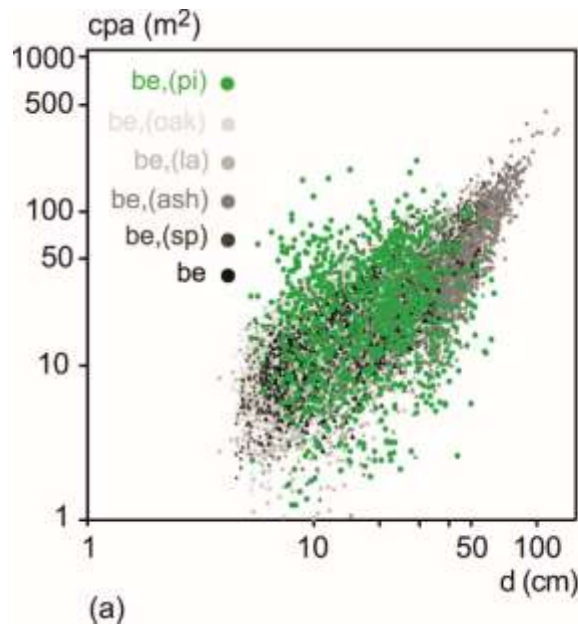
S. pine
s. oak
E. ash
E. larch
N. spruce

Allometry between crown projection area and stem diameter of European beech when growing in mono-specific versus mixed stands
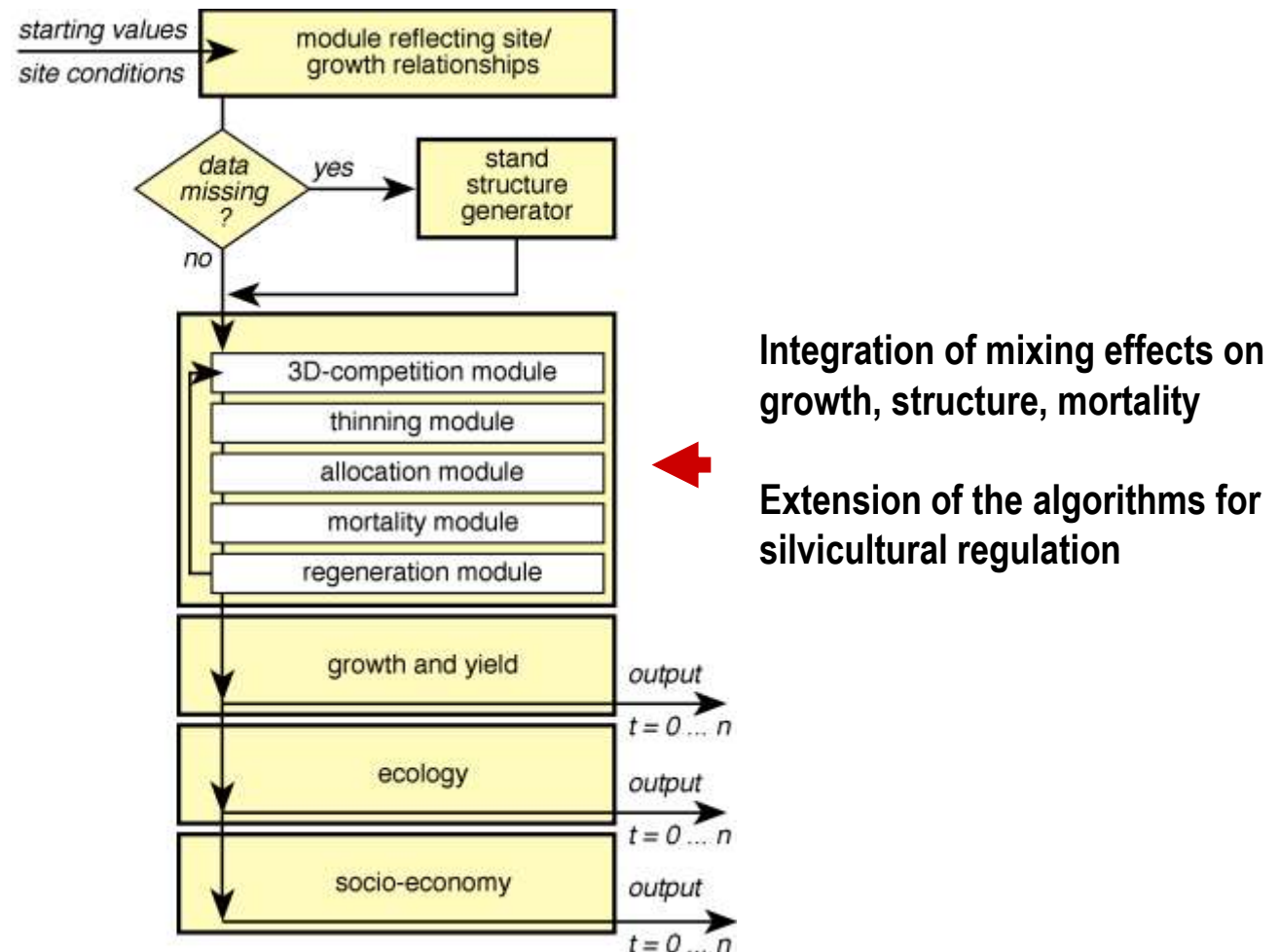
Summary 2:

Mixed stands showed compared with pure stands among others:
- overyielding by 10-30 %
- higher stand density but similar dq, hq
- wider tree size range, greater tree size inequality, heterogeneity
- different tree allometry

SILVA 3.0 as example of a spatially explicit individual tree model for pure and mixed stands

Integration of mixing effects on growth, structure, mortality

Extension of the algorithms for silvicultural regulation

Rules and algorithms for initiating the regeneration depending on the density of the overstorey

Pretzsch H, Forrester D, Bauhus J (2017) Mixed-species forests. Ecology and Management, Springer, Berlin, 653 p
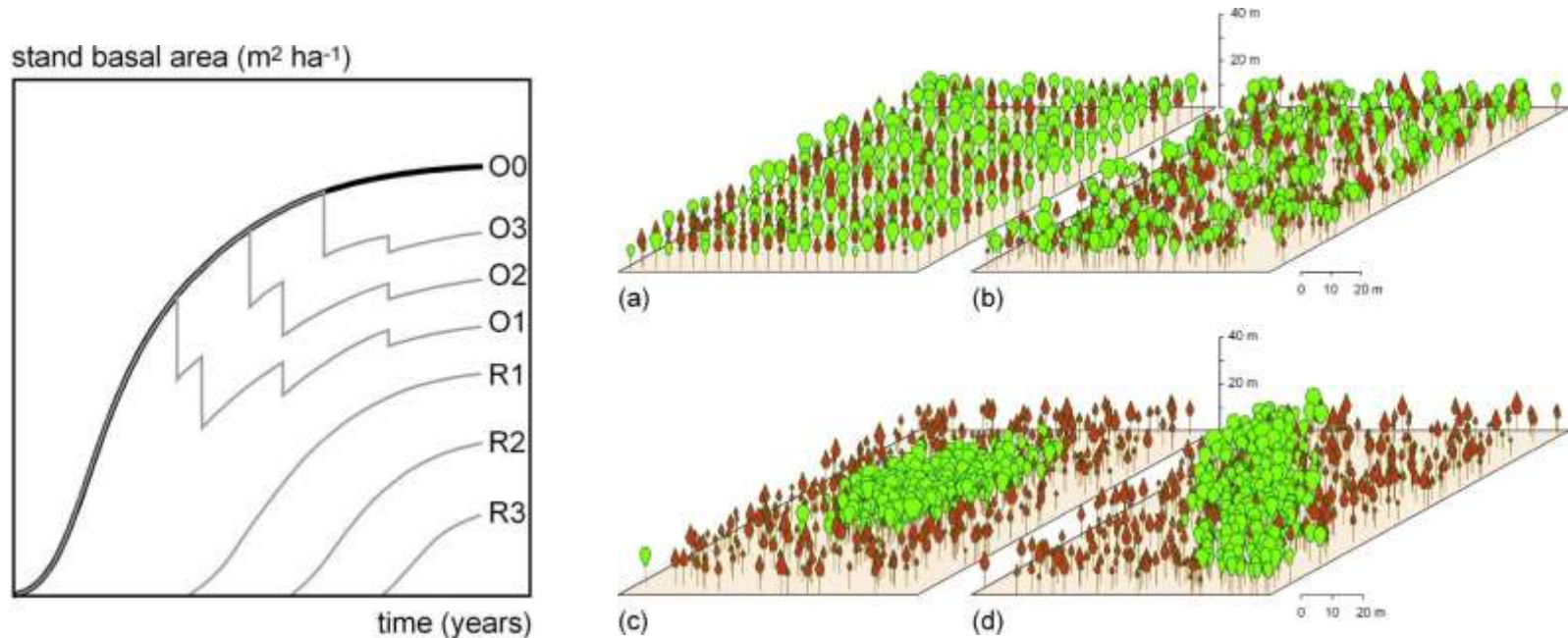
Rules and algorithms for regulation of competition by spatial or temporal separation
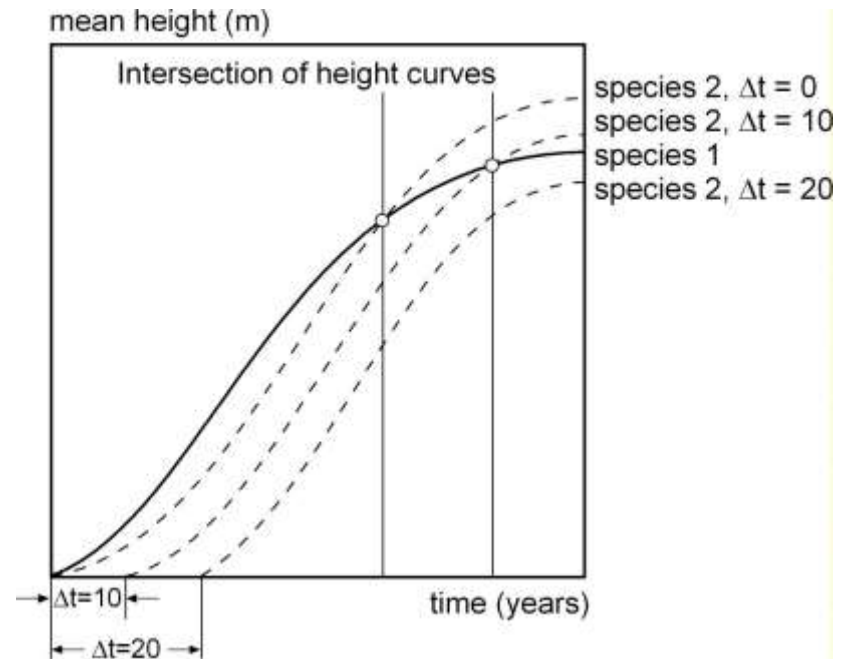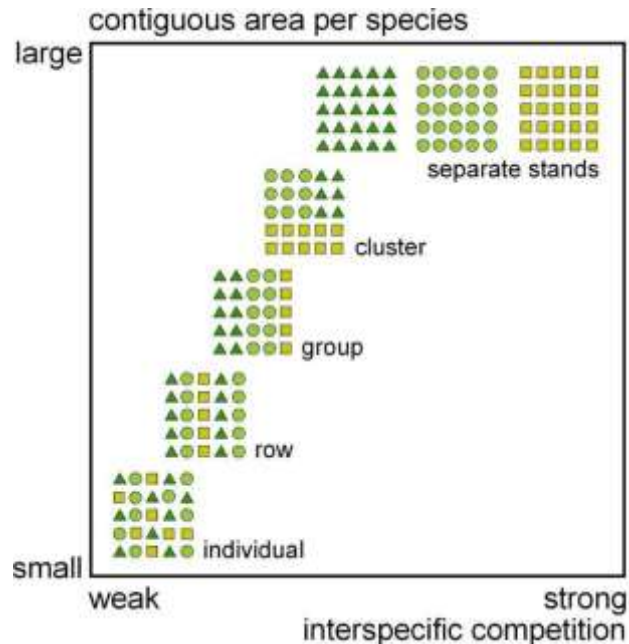
Pretzsch H, Forrester D, Bauhus J (2017) Mixed-species forests. Ecology and Management, Springer, Berlin, 653 p

Rules and algorithms for regulation of stand density and species-specific mixing proportions

Pretzsch H, Forrester D, Bauhus J (2017) Mixed-species forests. Ecology and Management, Springer, Berlin, 653 p

Rules and algorithms for regulation of stand density and species-specific mixing proportions

Summary 3:

Rules and algorithms in models are required for:
- artificial and natural regeneration
- spatial and temporal separation of species
- regulation of stand density
- mixing proportions, based on the species' space requirements

Pretzsch H, Forrester D, Bauhus J (2017) Mixed-species forests. Ecology and Management, Springer, Berlin, 653 p
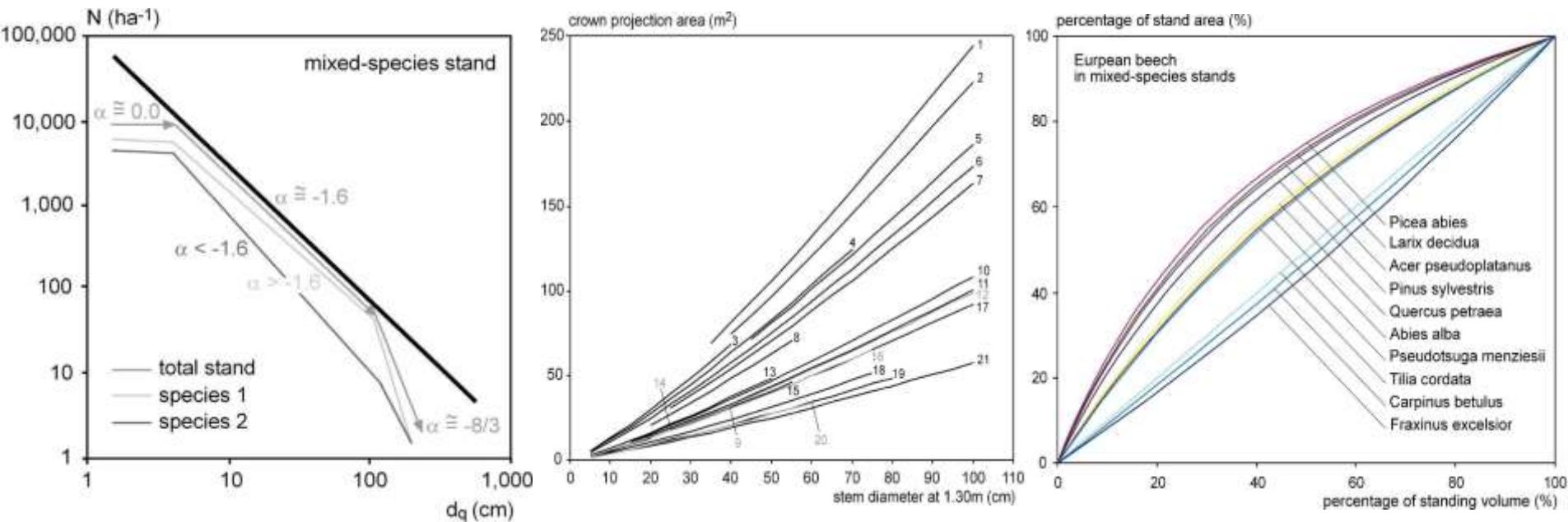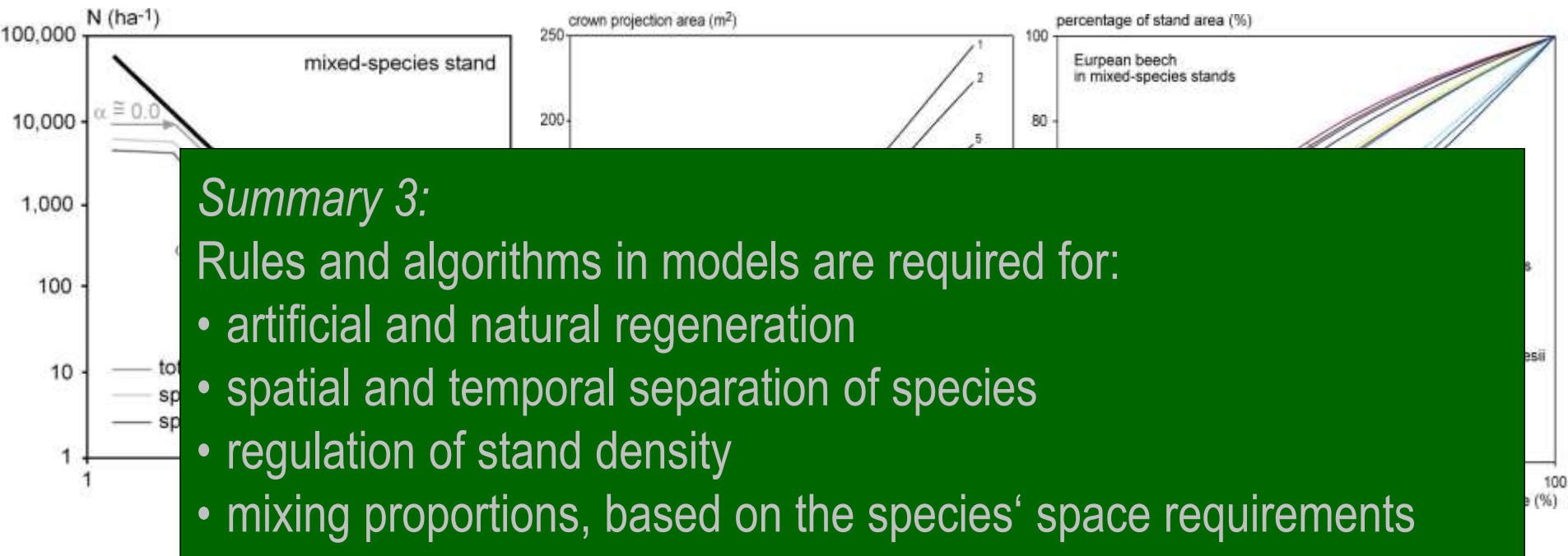
Knowledge gaps and next steps

- stand density and mixing effects

- effect of different spatial mixing patterns (e.g., individual tree, group, cluster)

- mixing effects depending on site conditions

- effect of mixing on tree allometry, structure, wood quality

- further analyses of essential mixtures, e.g., pine/oak, E. beech/Douglas-fir, spruce/fir/beech

Summary and conclusions

- In order to bring mixed-species stands on the ground in forest practice we need quantitative silvicultural guidelines

- The development of guidelines requires models for scenario analyses

- The currently available models need adaptation to mixed-species stands

- For this purpose knowledge of mixing effects should be extended and integrated into models

- Essential is finally the formulation and integration of rules and algorithms for silvicultural regulation

Thanks for funding and support: