Waldwachstumskunde
Systemanalyse

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

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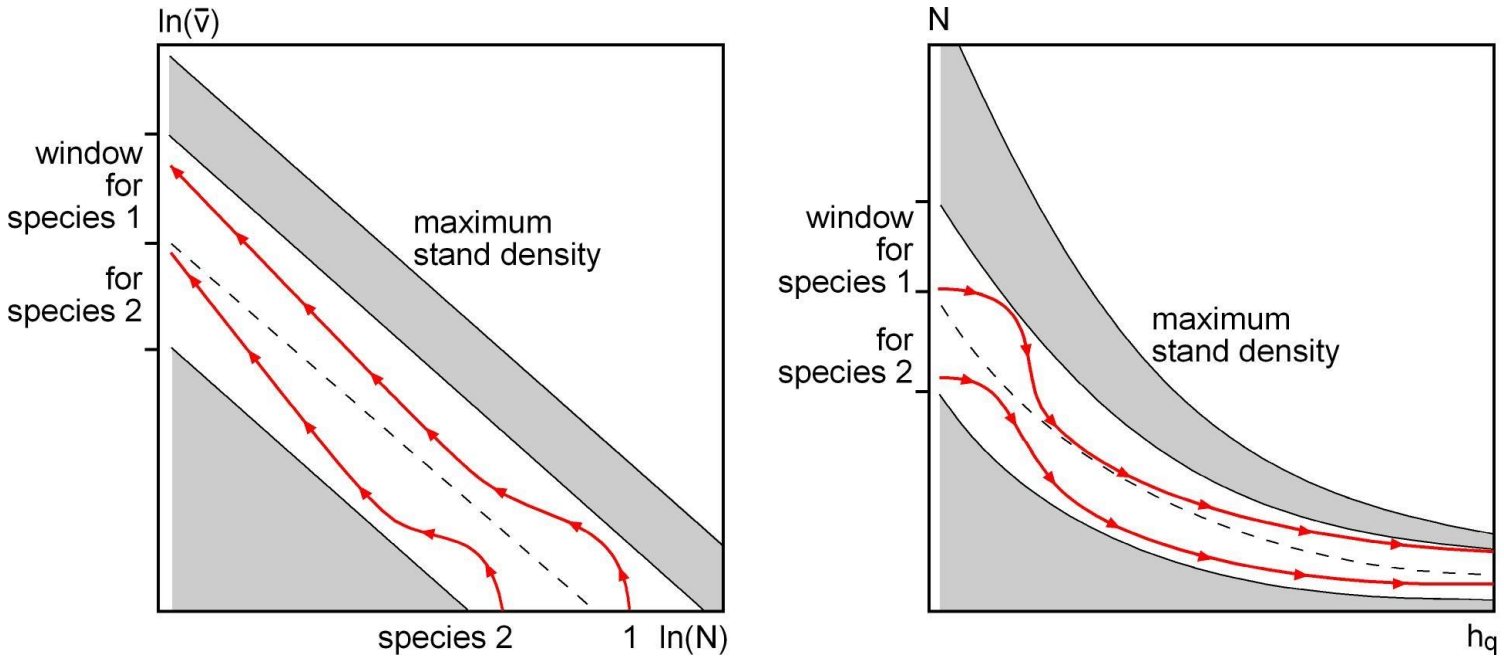
1 Need for silvicultural guidelines and models for mixed-species stands

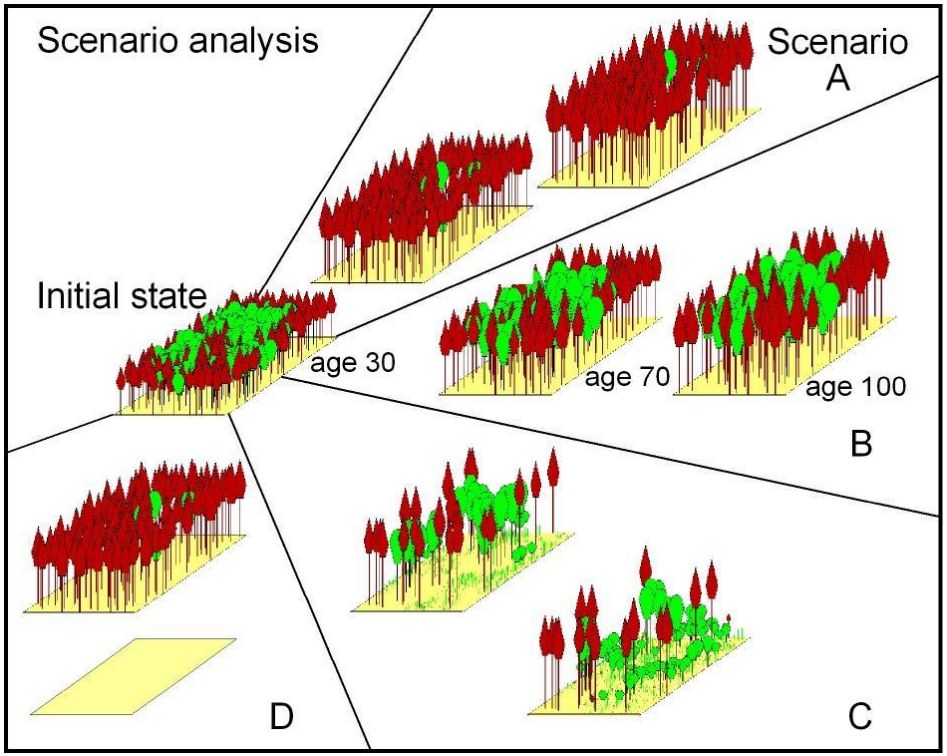
2 Key mixing effects on tree and stand dynamics

3 Measures for silvicultural regulation of mixed-species stands

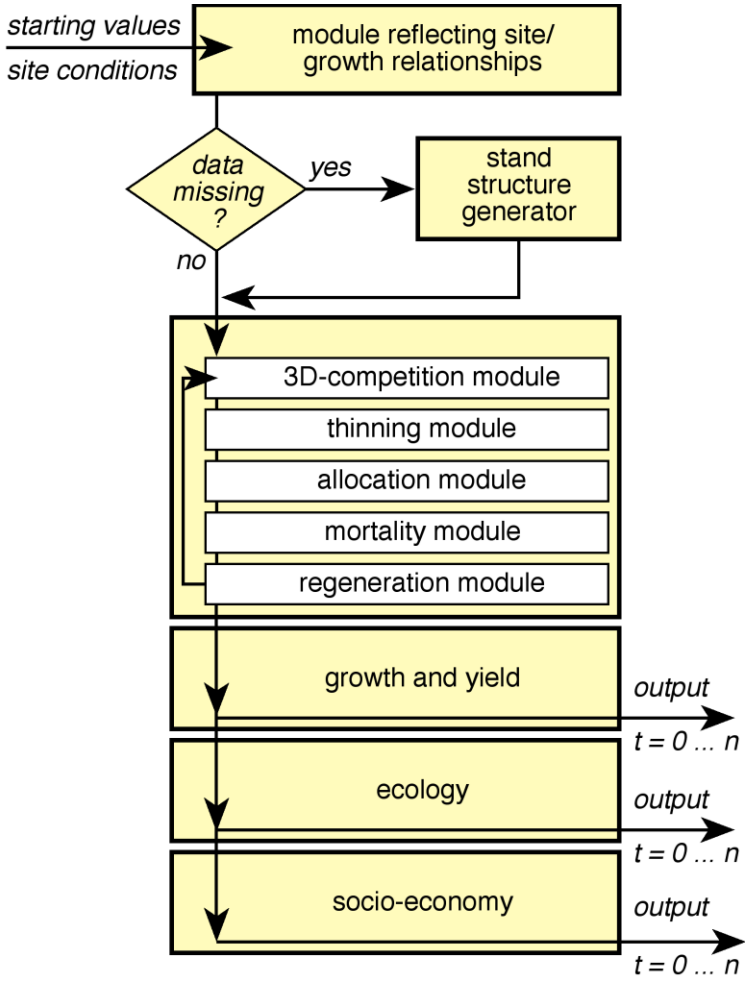
Guidelines for silvicultural regulation of mixed-species stand can bring the mixing idea onto the ground



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



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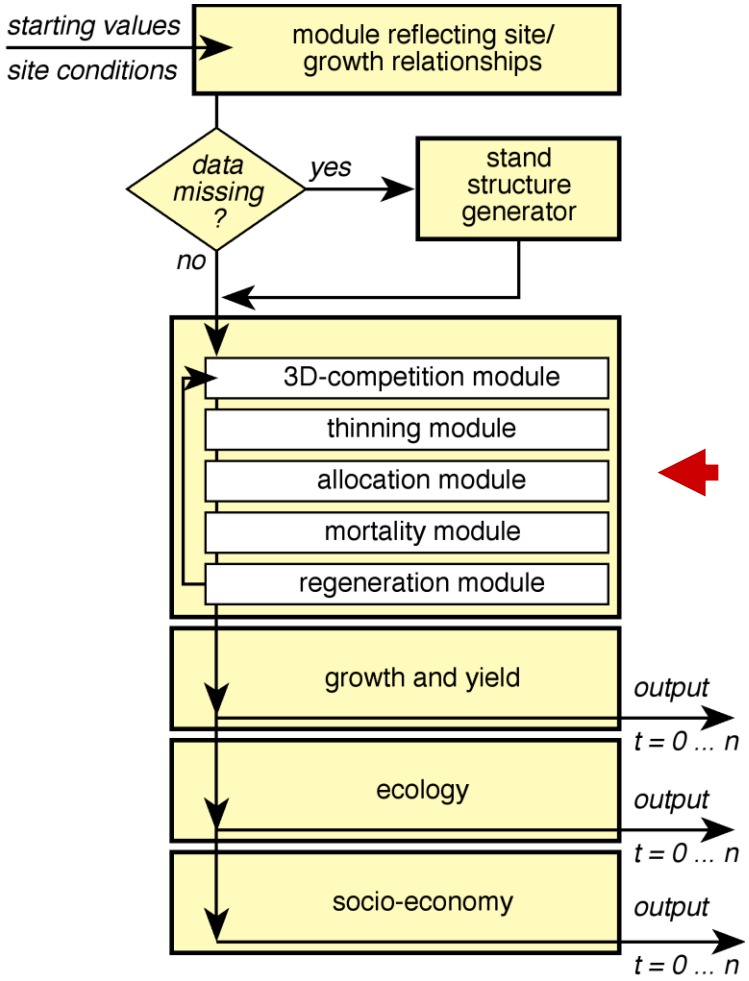

Integration of mixing effects on growth, structure, mortality

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

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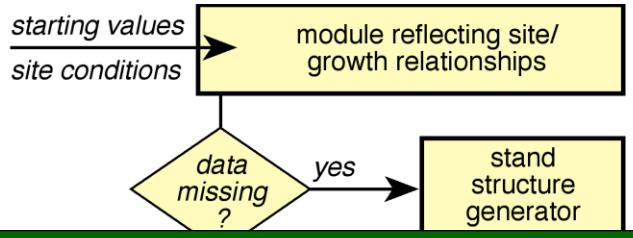
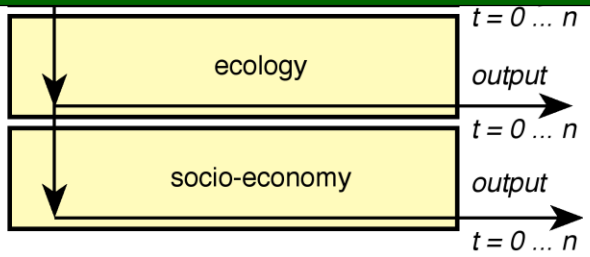


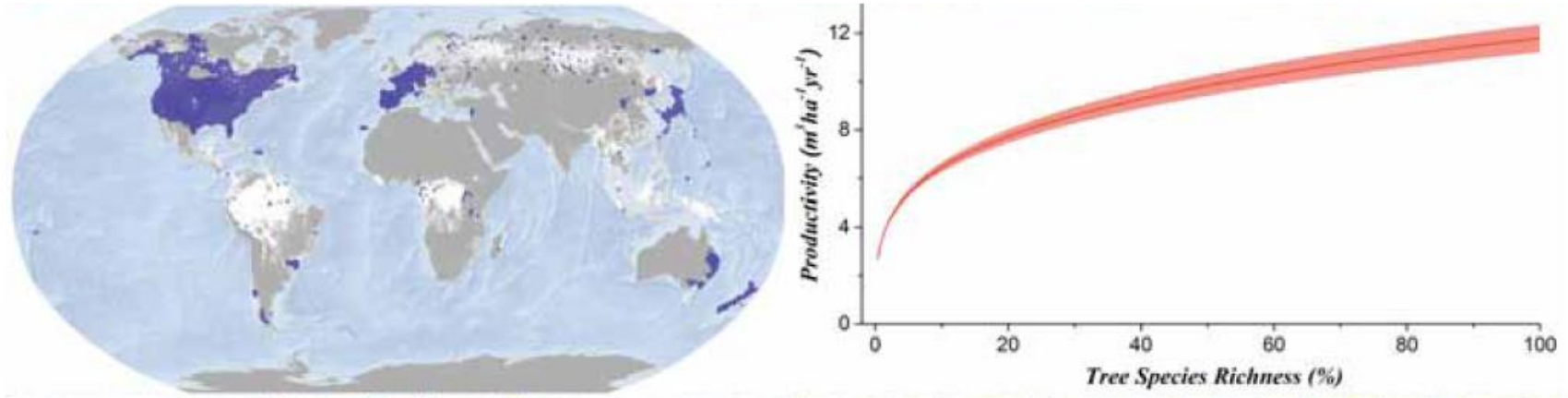
Summary 1:

- 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



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

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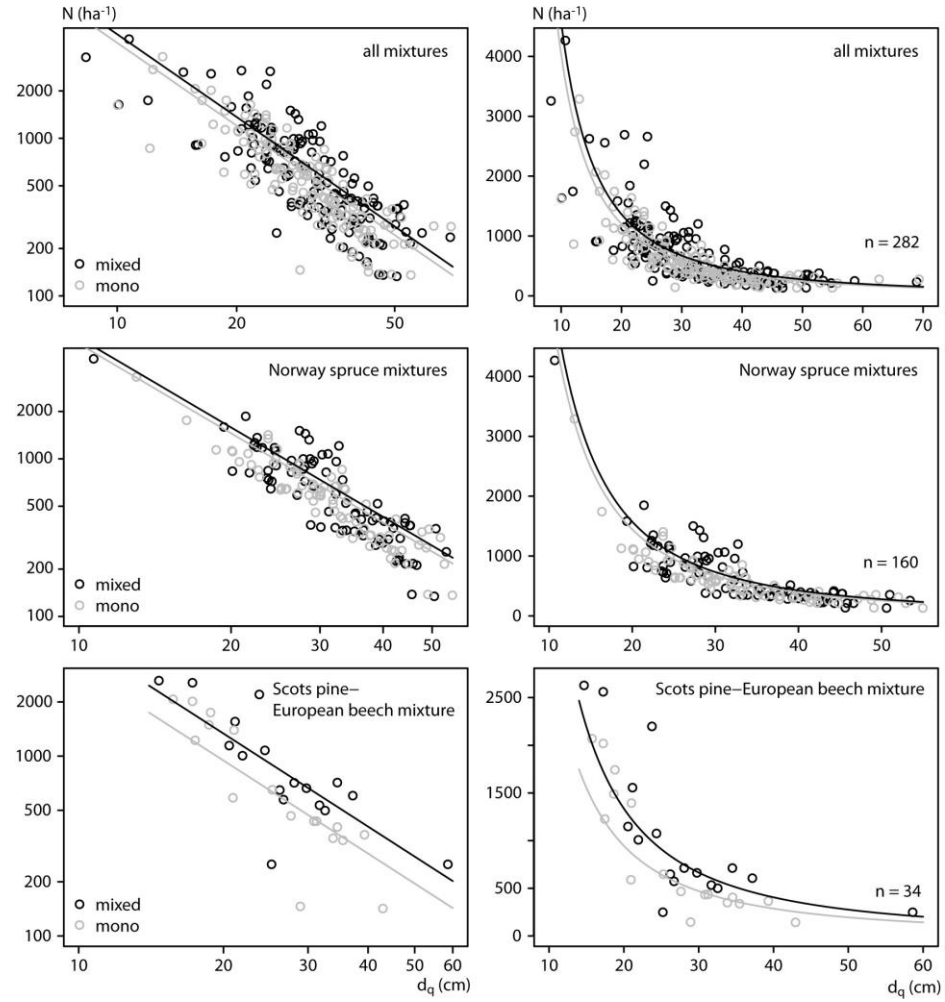
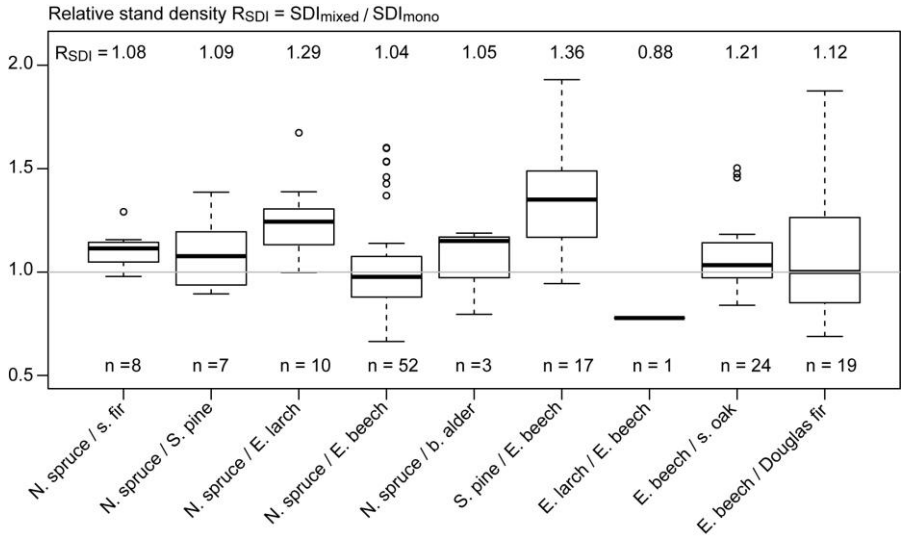
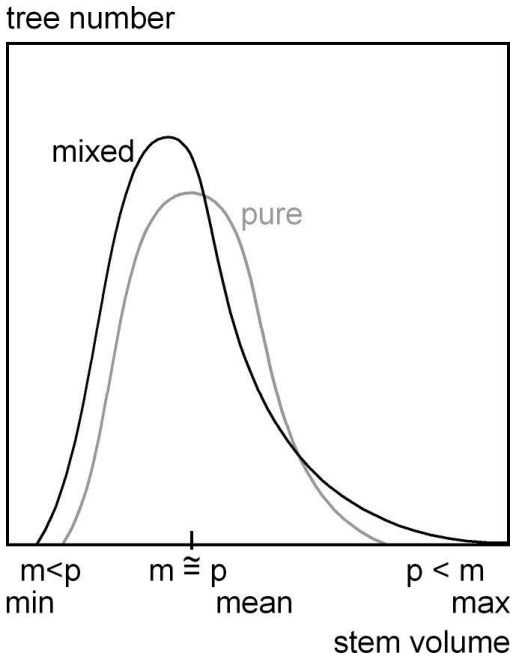
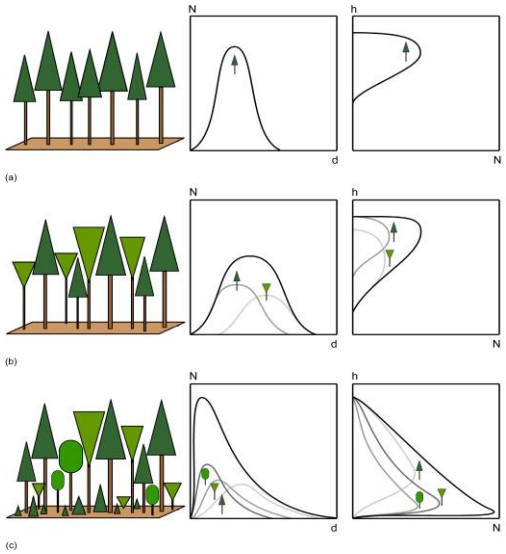
Effect of tree species mixing on stand density represented by self-thinning line and SDI

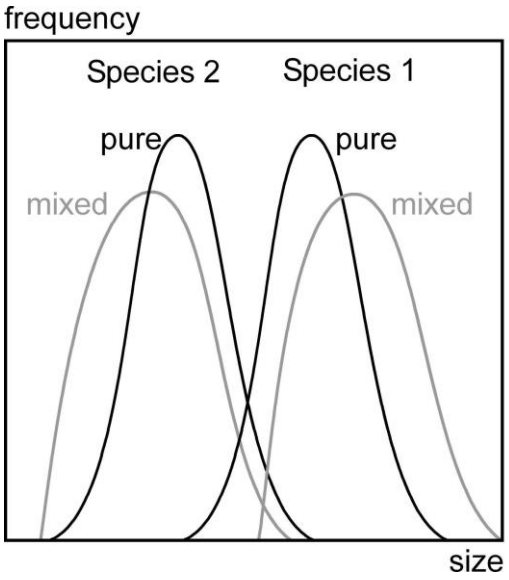




Wider size range, stronger right-skewness in mixed stands; more vertical heterogeneity, often species 1 ahead, species 2 behind

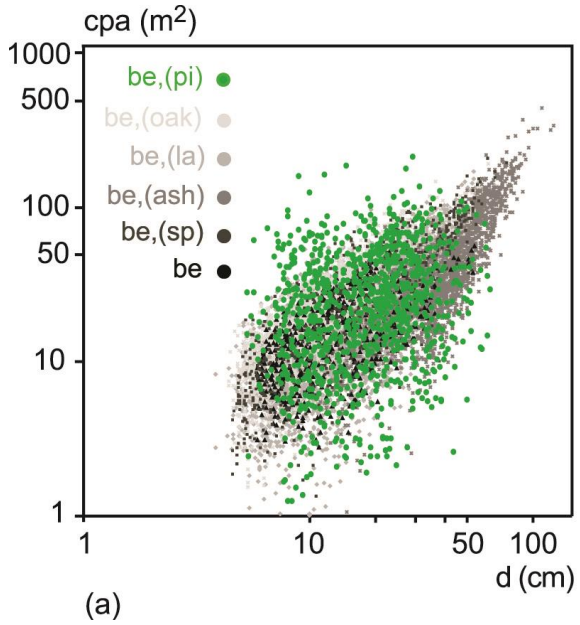


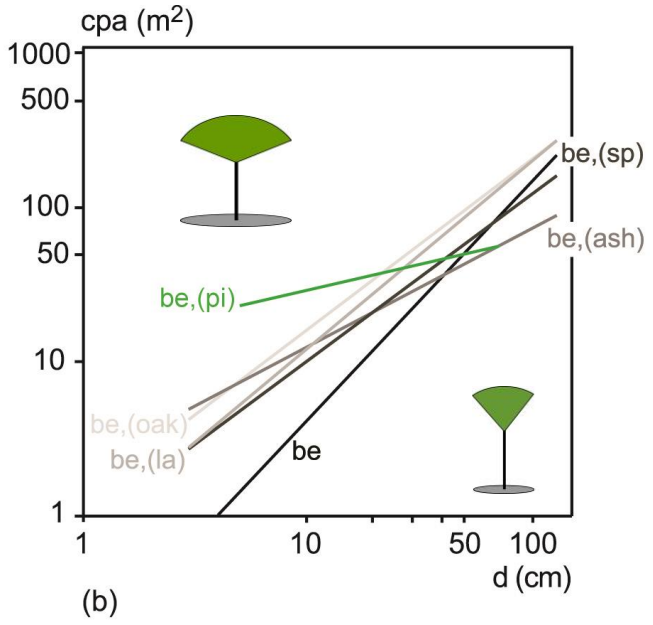




Pretzsch, H., Schütze, G. (2014) Size-structure dynamics of mixed versus pure forest stands, Forest Systems, 23(3):560-572.

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





S. pine
s. oak
E. ash
E. larch
N. spruce

Pretzsch, H. (2014) Canopy space filling and tree crown morphology in mixed-species stands compared with monocultures. Forest Ecology and Management, 327: 251-264.

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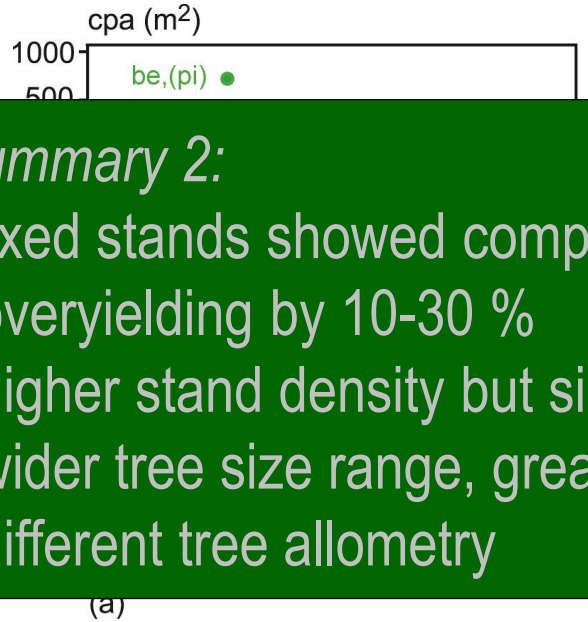

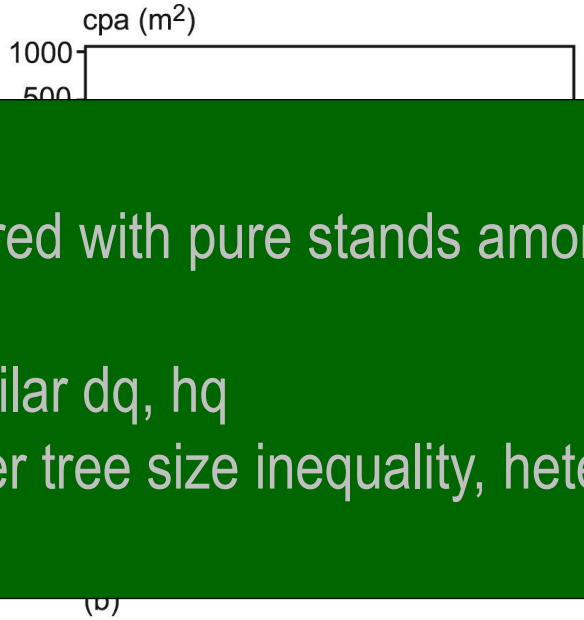

Summary 2:

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

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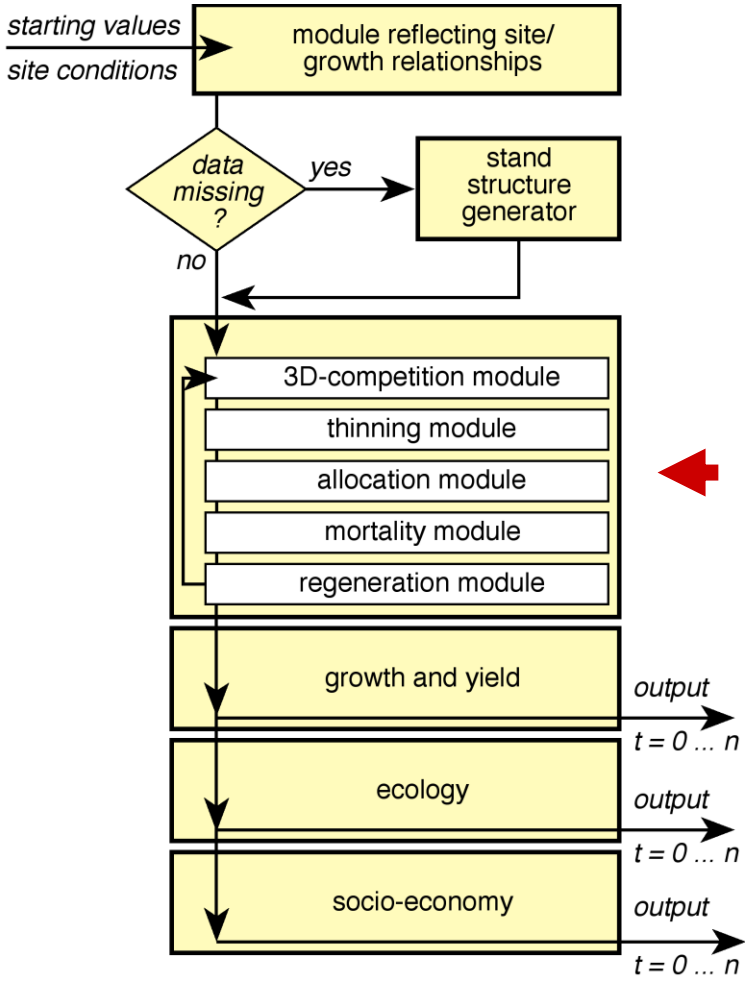

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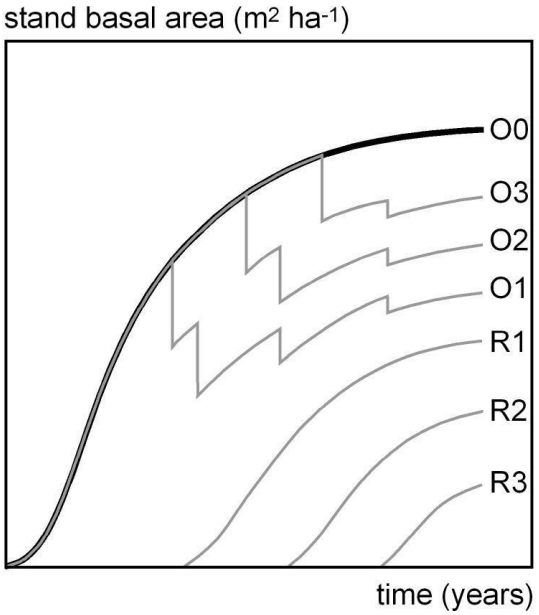
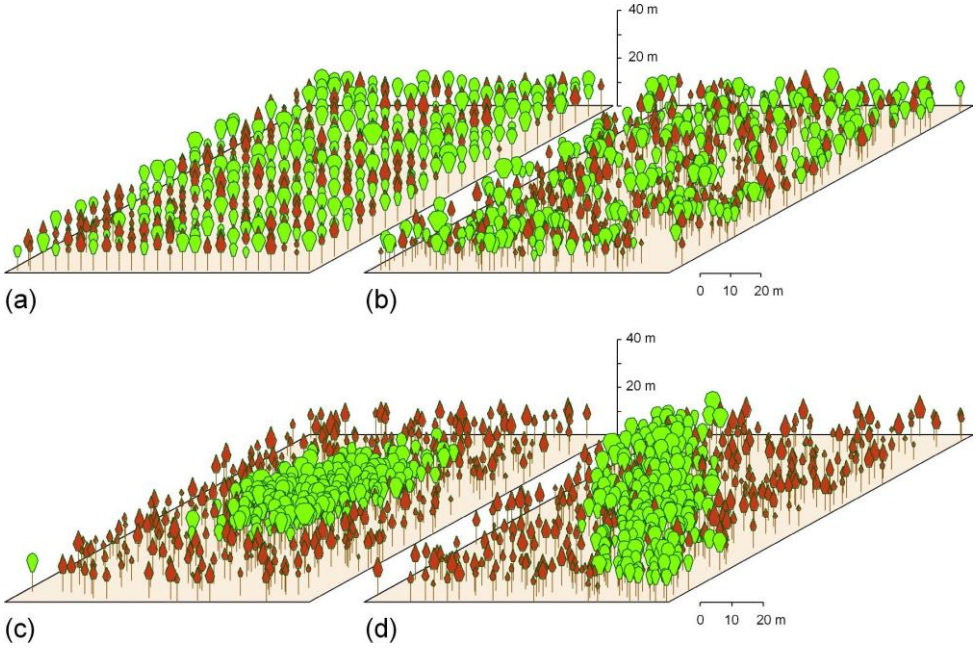
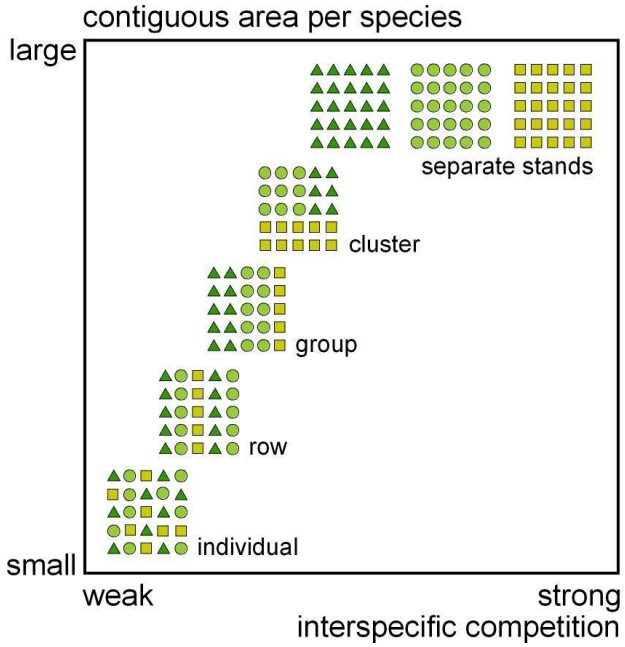
Rules and algorithms for initiating the regeneration depending on the density of the overstorey

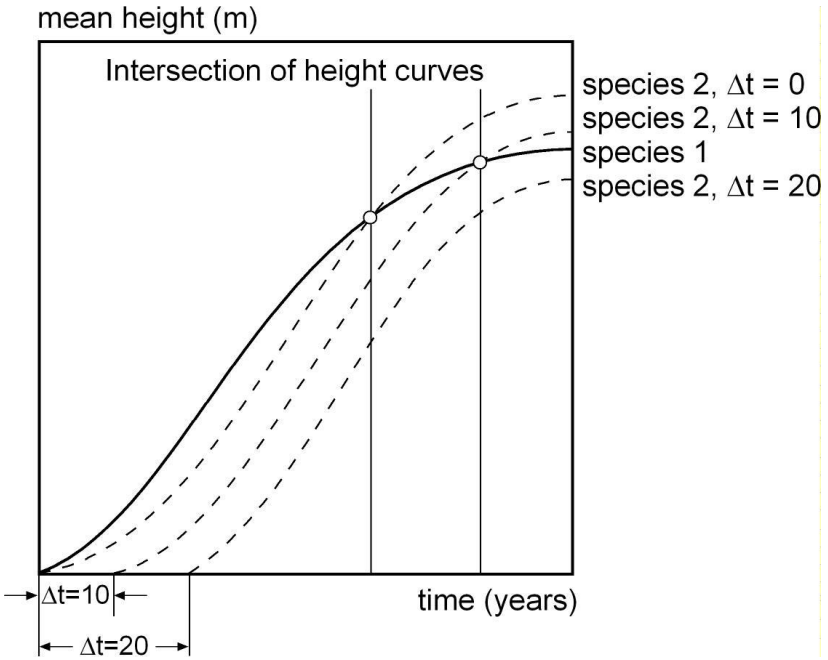




Pretzsch H, Forrester D, Bauhus J (2017) Mixed-species forests. Ecology and Management, Springer, Berlin, 653 p

Rules and algorithms for regulation of competition by spatial or temporal separation





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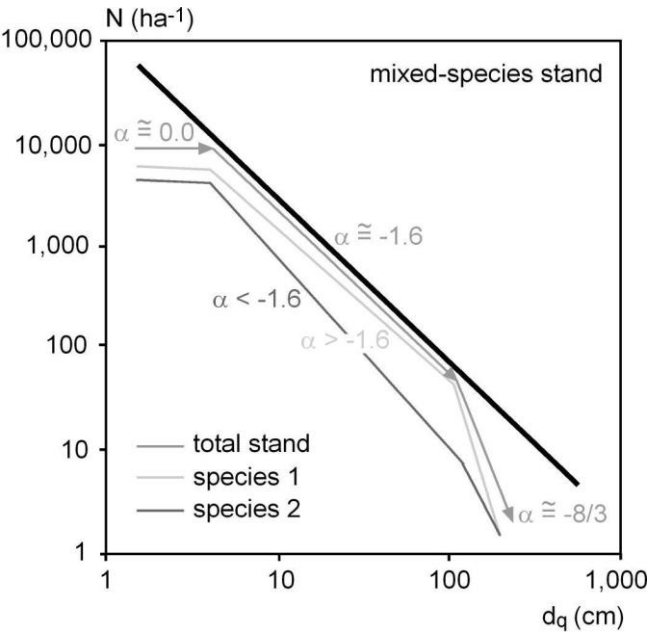
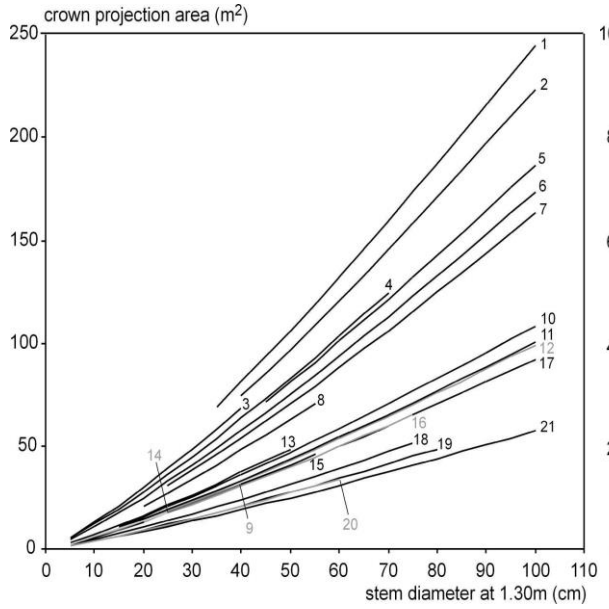
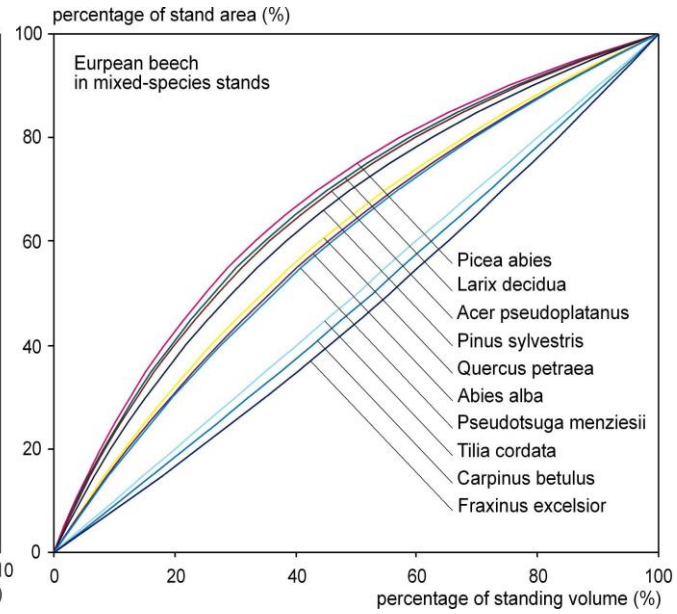
Rules and algorithms for regulation of stand density and species-specific mixing proportions







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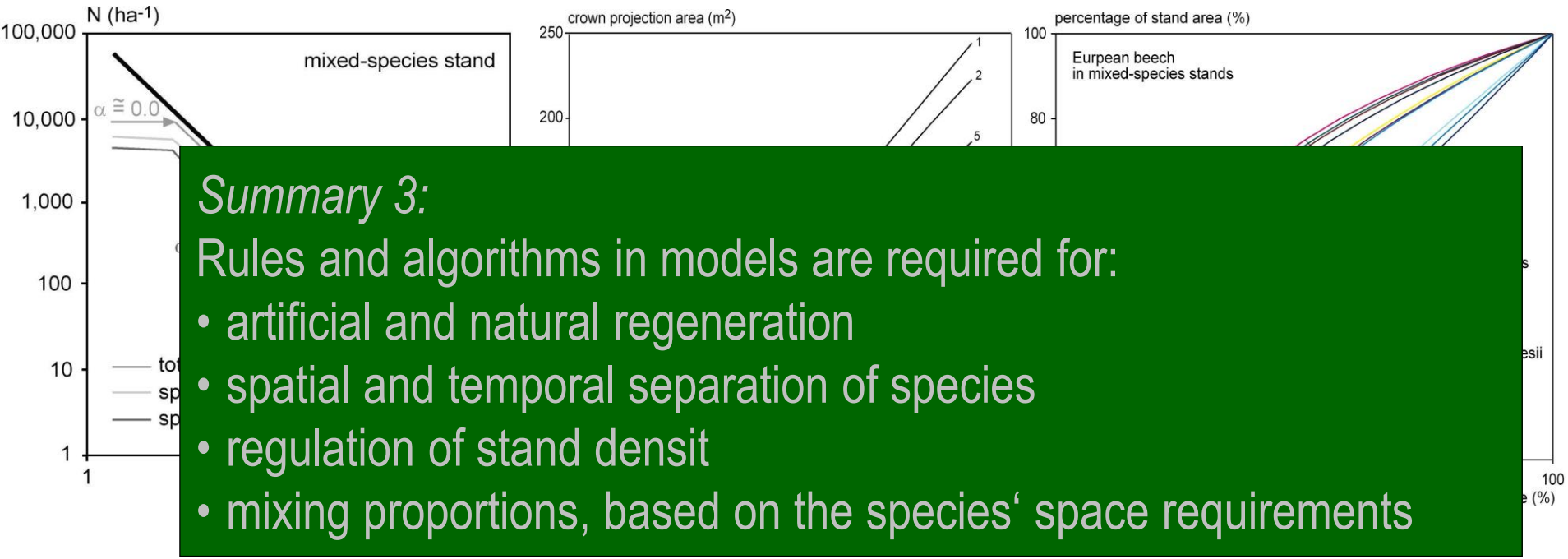

Summary 3:

Rules and algorithms in models are required for:

- artificial and natural regeneration
- spatial and temporal separation of species
- regulation of stand densit
- mixing proportions, based on the species‘ space requirements

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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

Criteria for sustainable forest ecosystem management. Objective hierarchy for the management of municipal forest Traunstein

Criteria for sustainable forest management	Indicators	Weight (%)
Forest resources	timber resources, area of forest, extension of area	20
Health and vitality	stability, fitness, elasticity	17
Productive functions	growth, yield, net return	12
Biological diversity	habitat quality, richness flora/fauna, conservation	10
Protective functions	soil, water, climate, noise, protection	10
Socio-economic functions	employment, recreation, esthetics, proximity to nature	31

Gesamteuropäische Kriterien 1-6 und Indikatoren für die nachhaltige Bewirtschaftung von Wäldern

	Kriterien	Indikatoren (beispielhaft)
1	Forstliche Ressourcen	Waldfläche, Kohlenstoffvorrat, Alters- und Durchmesserstruktur, …
2	Gesundheit und Vitalität	chem. Bodenzustand, Nadel- und Blattverluste, Deposition, …
3	Produktionsfunktionen	Zuwachs, Hiebsatz, Nichtholzprodukte, …
4	Biologische Diversität	Baumartenvielfalt, Naturnähe, Totholzvorrat, Landschaftsdiversität, …
5	Schutzfunktionen	Anteil Schutzwälder für Klima, Boden, Wasser, …
6	Sozio-ökonomische Funktionen	Waldreinertrag, Anzahl der Beschäftigten, Landschaftsbild, …

nach MCPFE, 2000