Waldwachstumskunde
Systemanalyse

Towards silvicultural prescriptions for mixed-species stands

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http://waldwachstum.wzw.tum.de/index.php?id=presentations

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Formulas for mixing regulation with the Density equivalence coefficient, DEC

Species proportion of numbers of trees (m_{N1}, m_{N2}, where $m_{N1}+m_{N2}=1$)

$$N_{1,(2)} = N_{1,\underline{2}} \times (1/DEC_{sp_2 \rightarrow sp_1} + 1/m_{N_1} - 1)^{-1}$$

$$N_{(1),2} = N_{1,\underline{2}} \times (1/(DEC_{sp_2 \rightarrow sp_1} \times m_{N_2}) - 1/DEC_{sp_2 \rightarrow sp_1} + 1)^{-1}$$

$$N_{1,2} = N_{1,\underline{2}} \times$$
$$\times \left((1/DEC_{sp_2 \rightarrow sp_1} + 1/m_{N_1} - 1)^{-1} + (1/(DEC_{sp_2 \rightarrow sp_1} \times m_{N_2}) - 1/DEC_{sp_2 \rightarrow sp_1} + 1)^{-1} \right)$$

Species proportion by area (m_{A1}, m_{A2}, where $m_{A1}+m_{A2}=1$)

$$N_{1,(2)} = N_{1,\underline{2}} \times m_{A_1} \times DEC_{sp_2 \rightarrow sp_1}$$

$$N_{(1),2} = N_{1,\underline{2}} \times m_{A_2}$$

$$N_{1,2} = N_{1,\underline{2}} \times (m_{A_1} \times DEC_{sp_2 \rightarrow sp_1} + m_{A_2})$$

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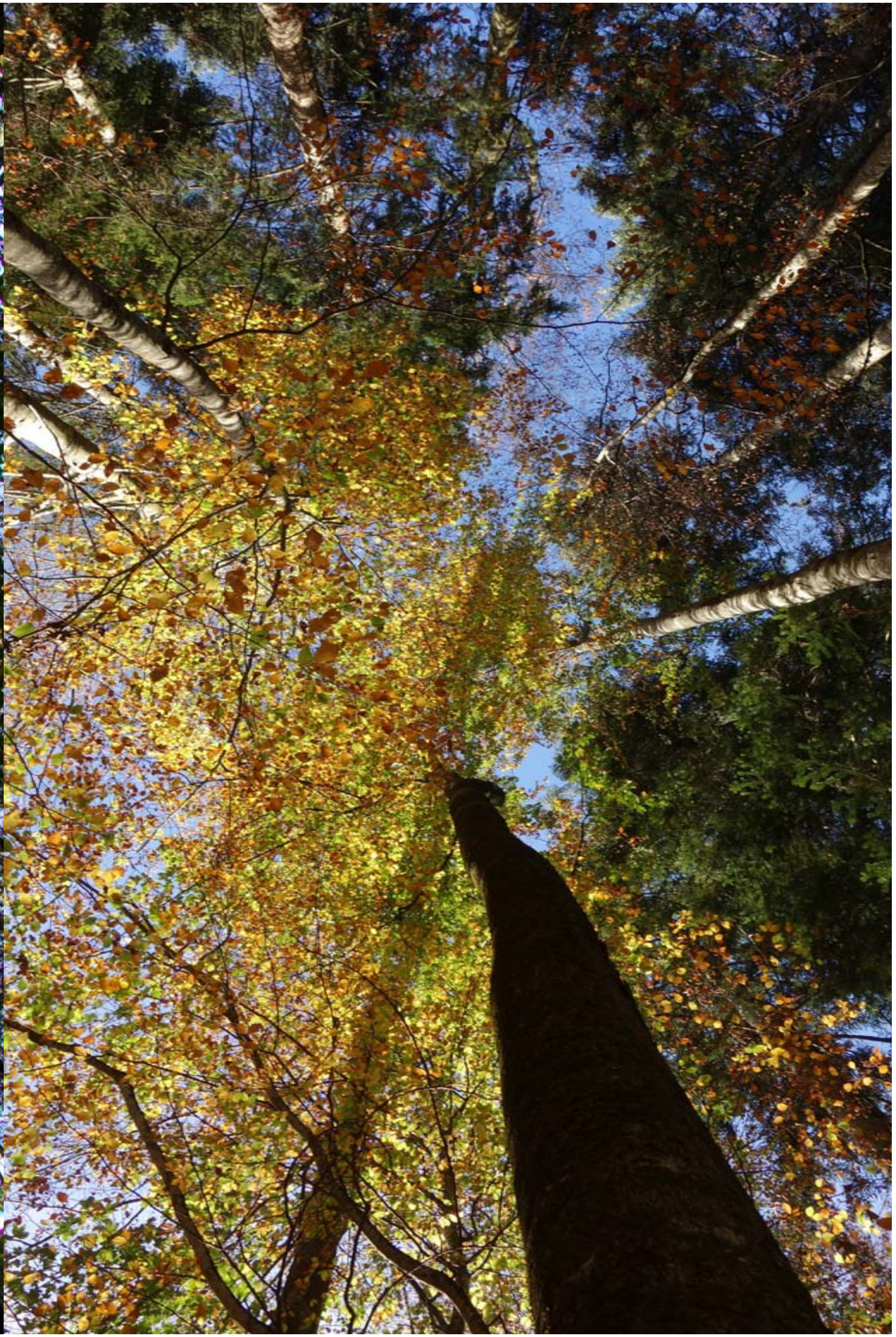
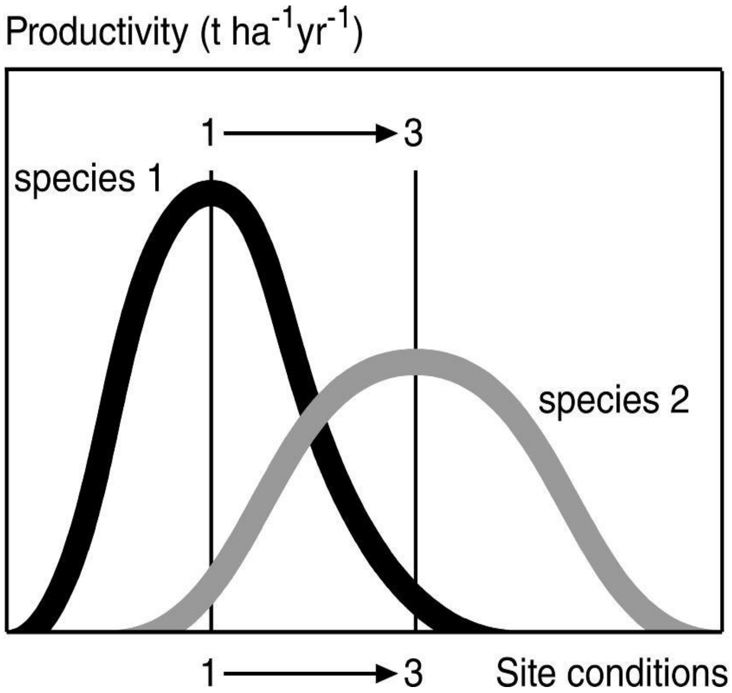
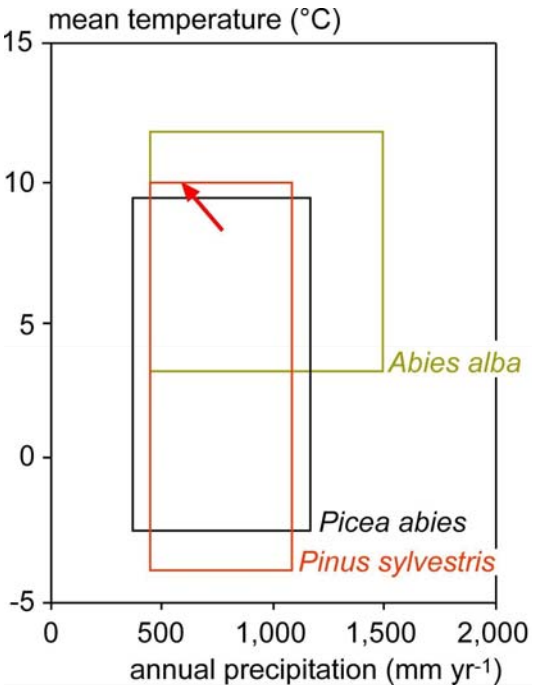
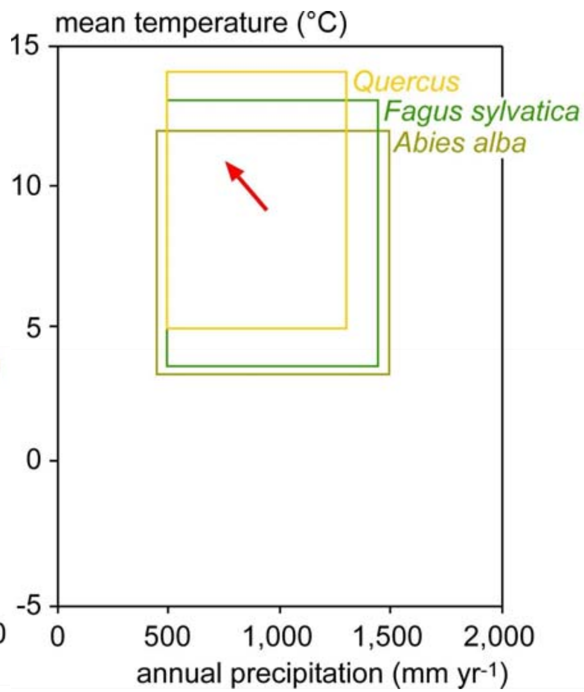
TUM

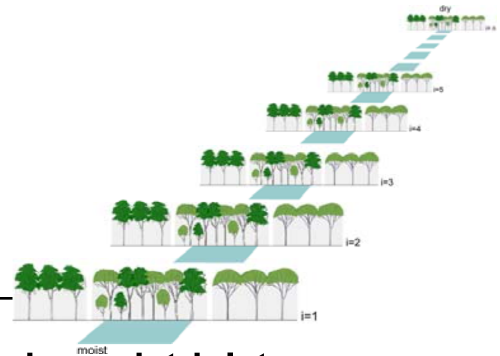



Species selection and mixing: Considering the ecological niches and especially the climate envelopes





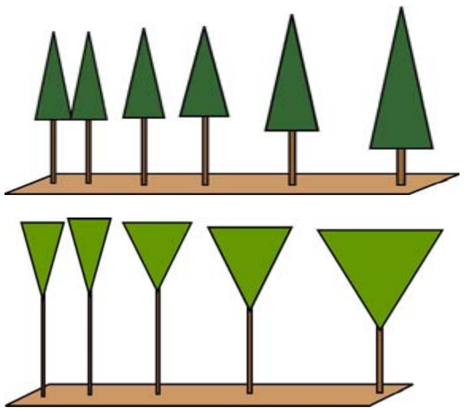




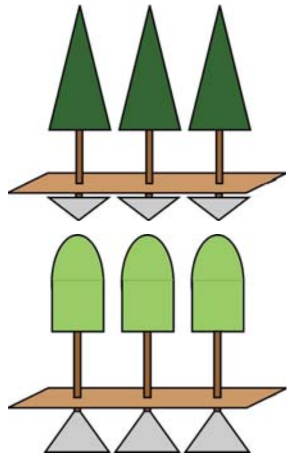
pine-oak triplets

Species mixing: Considering species complementary

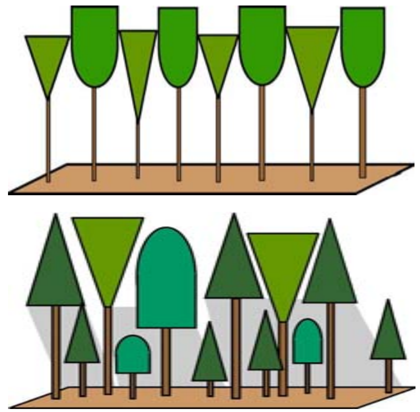
inplastic - plastic



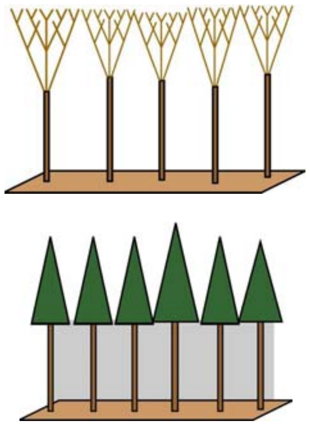
shallow – deep rooting



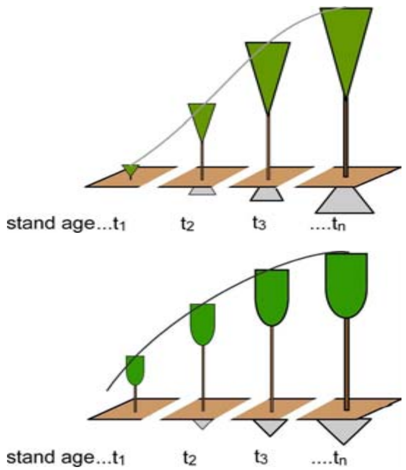
light demanding - shade tolerant



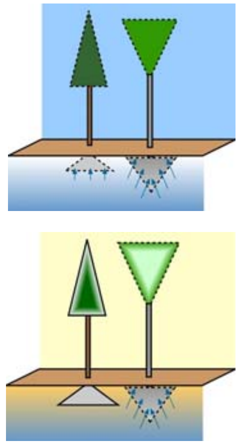
seasonal - evergreen



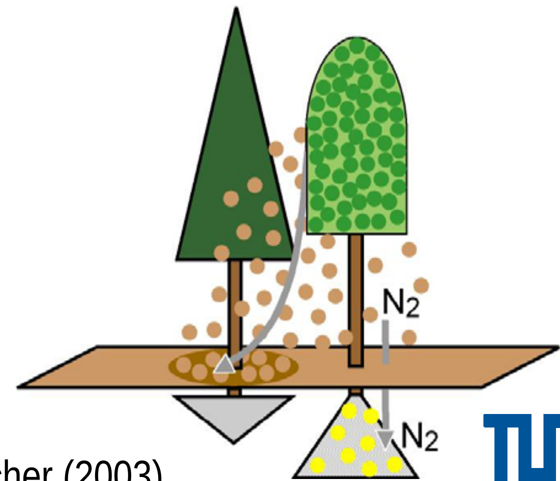
slow - fast growing



drought tolerant-intolerant

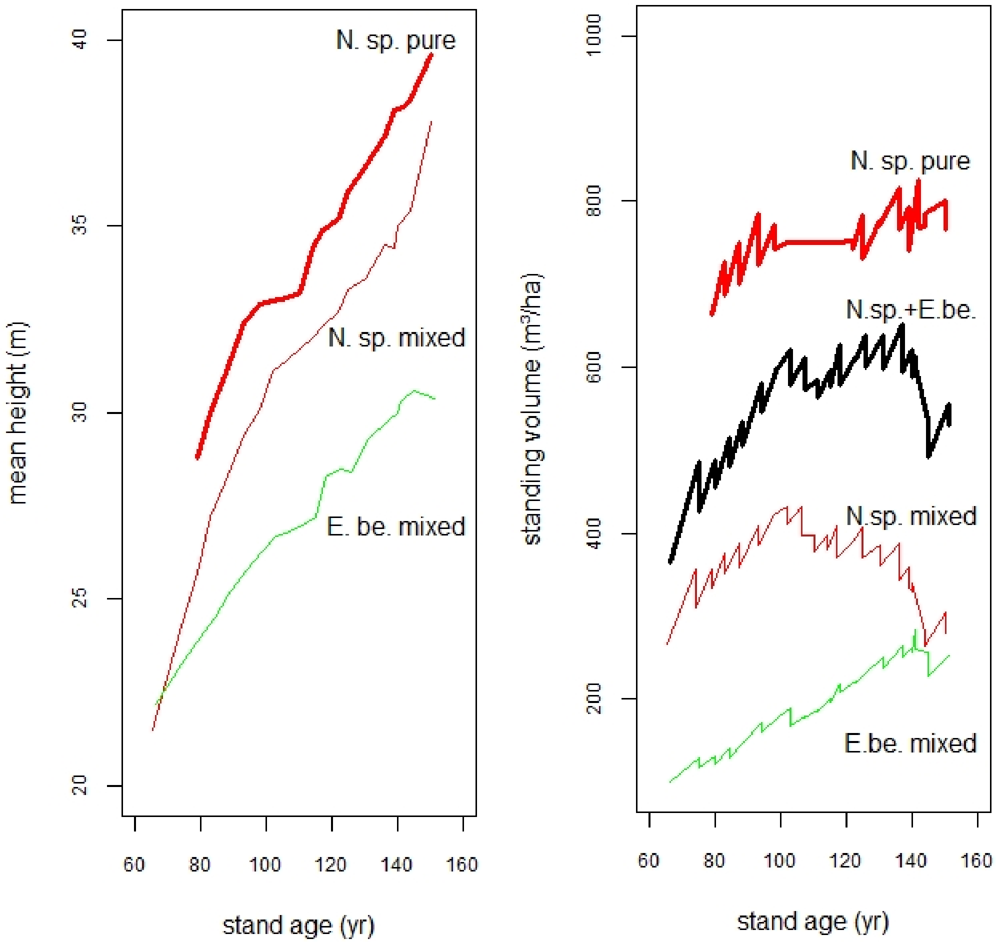


N-fixing - non N-fixing

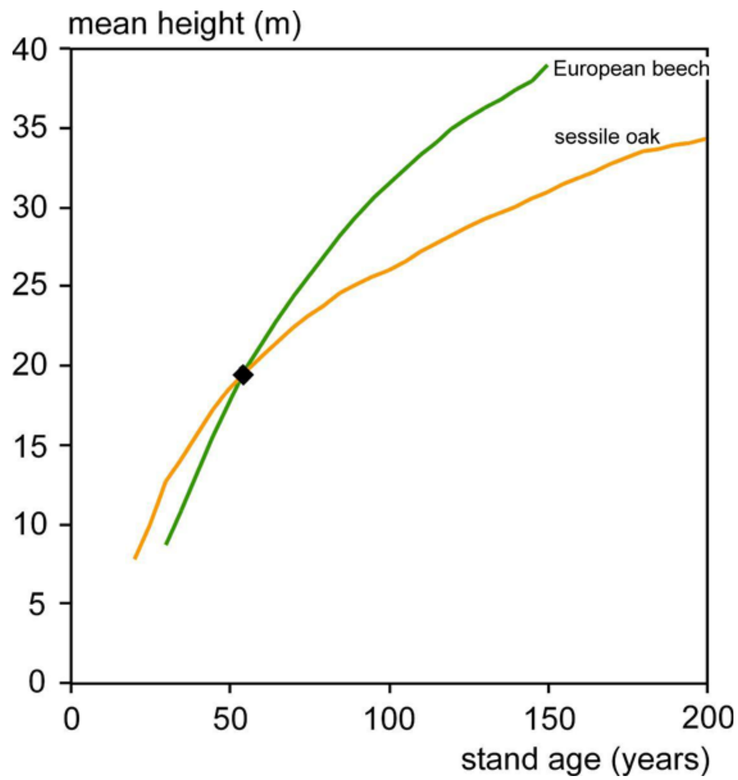


Ammer (2018), Pretzsch et al. (2017), Ellenberg and Leuschner (2010), Larcher (2003)

Potential problems: N. spruce and E. beech Oderhaus/Harz and E. beech s. oak/Steigerwald

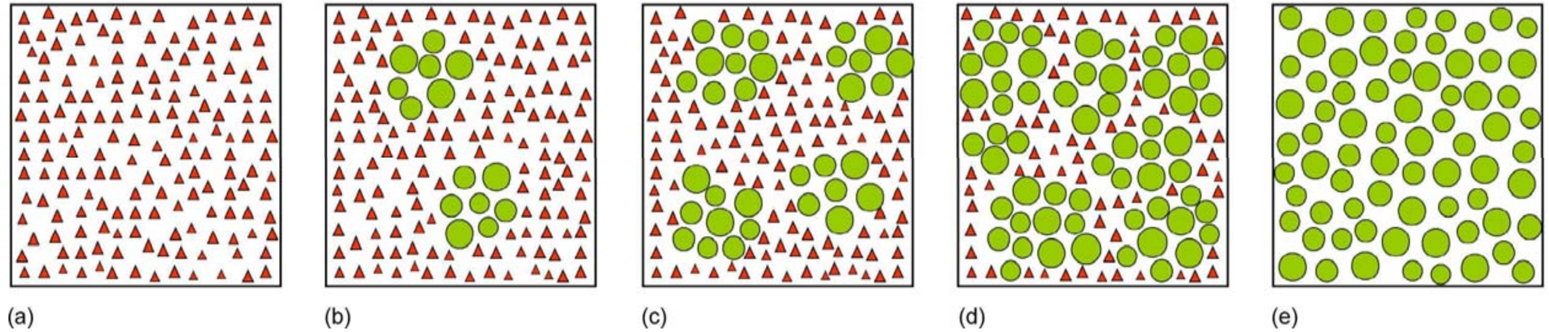


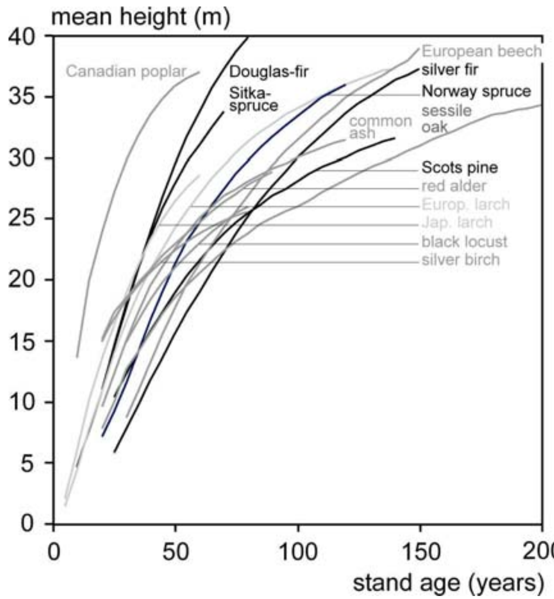
Lüpke v. B. and Spellmann, H (1997),
Pretzsch and Zenner (2017)

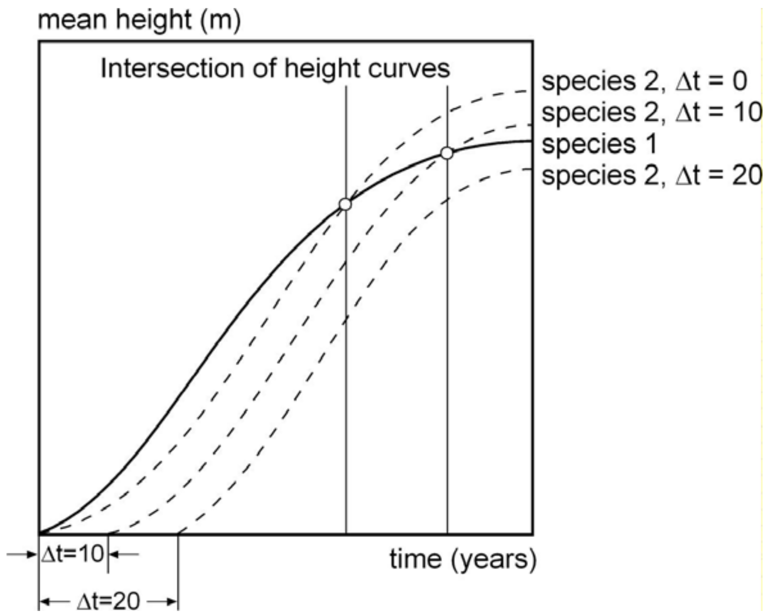


Pretzsch (2018)

Species mixing: Spatial and temporal separation







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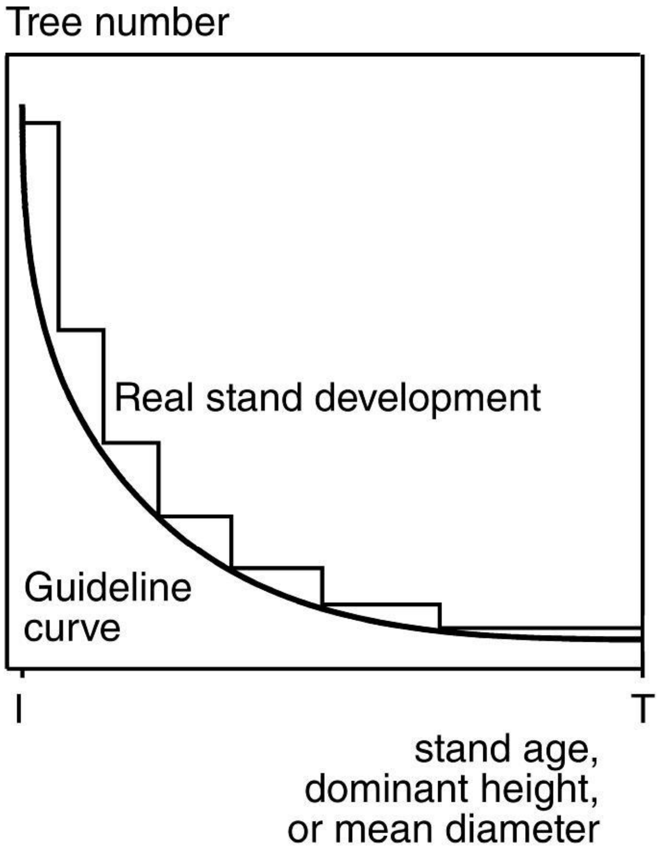
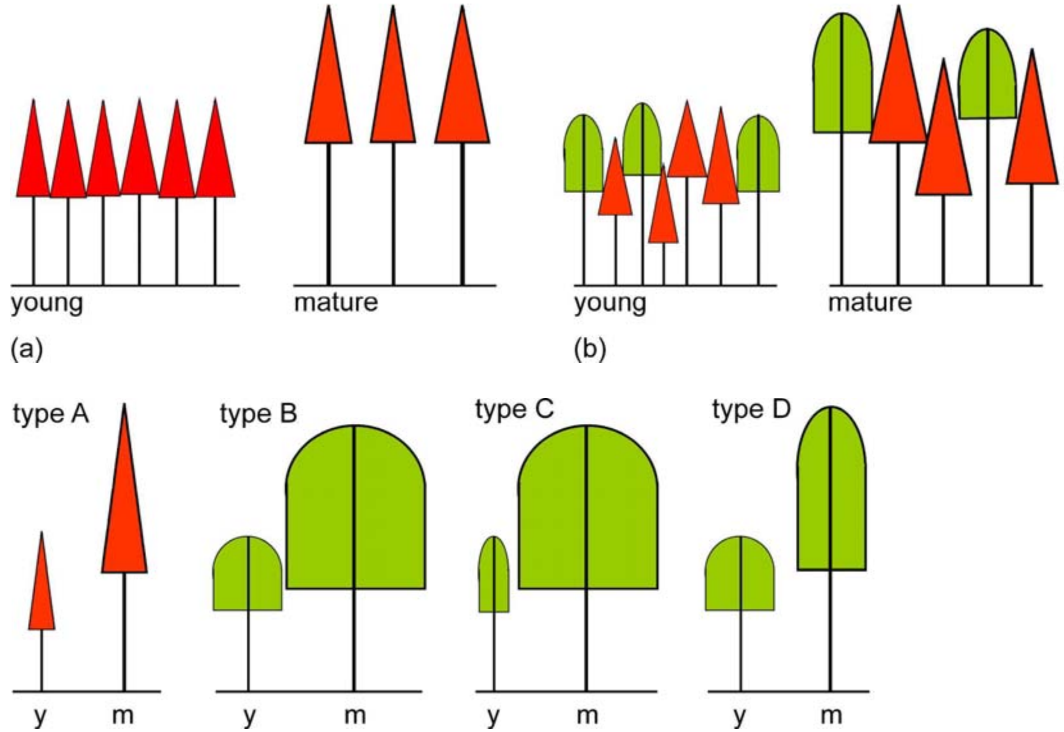
Application of guidelines for tree number reduction in mixtures: (1) max. density problem (2) growing space differences





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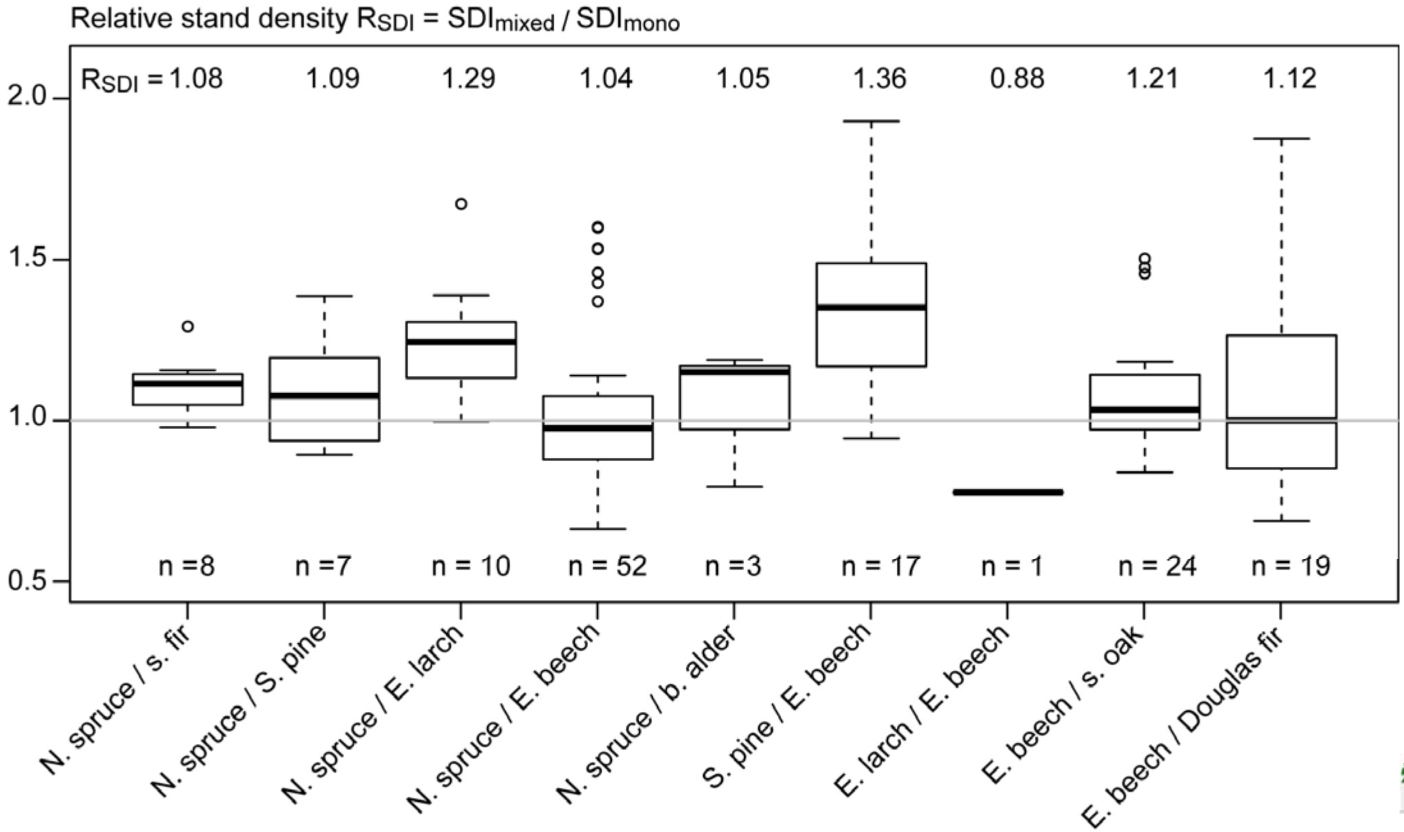
Problem 1: Max. density modification coefficients, DMC

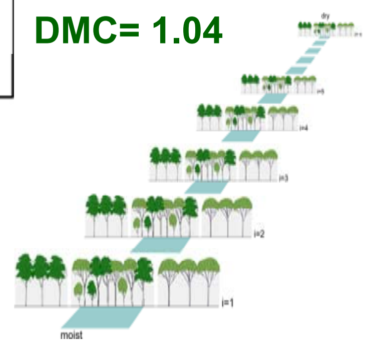
DMC = max. density mixed/max. density pure stand

Max. density mixed stand = max. density pure stand × DMC

DMC = 1.00 – 1.36

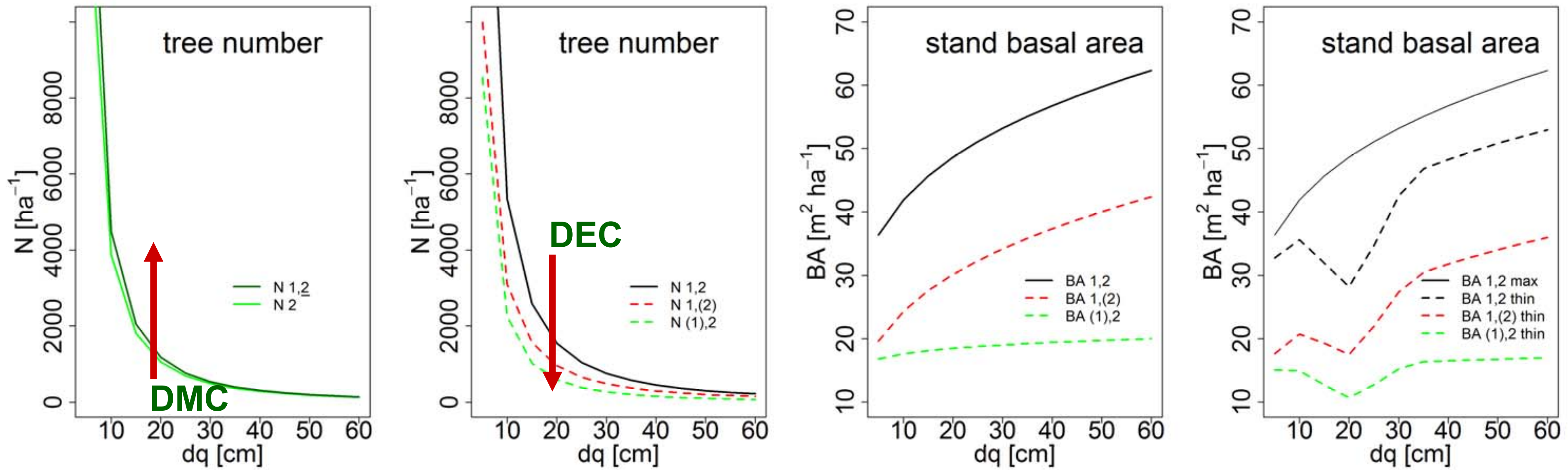


DMC= 1.04



pine-oak triplets

Application of DMC, DEC and density reduction



From max. tree number of reference species in monoculture to max tree number in mixture by DMC

From tree number of reference species to tree number of sp 1 and sp 2 in mixture by DEC

From tree number to stand basal area of sp.1 and2 area related mix 0.5:0.5

From max stand basal area to basal area of mixture area related mix 0.5:0.5

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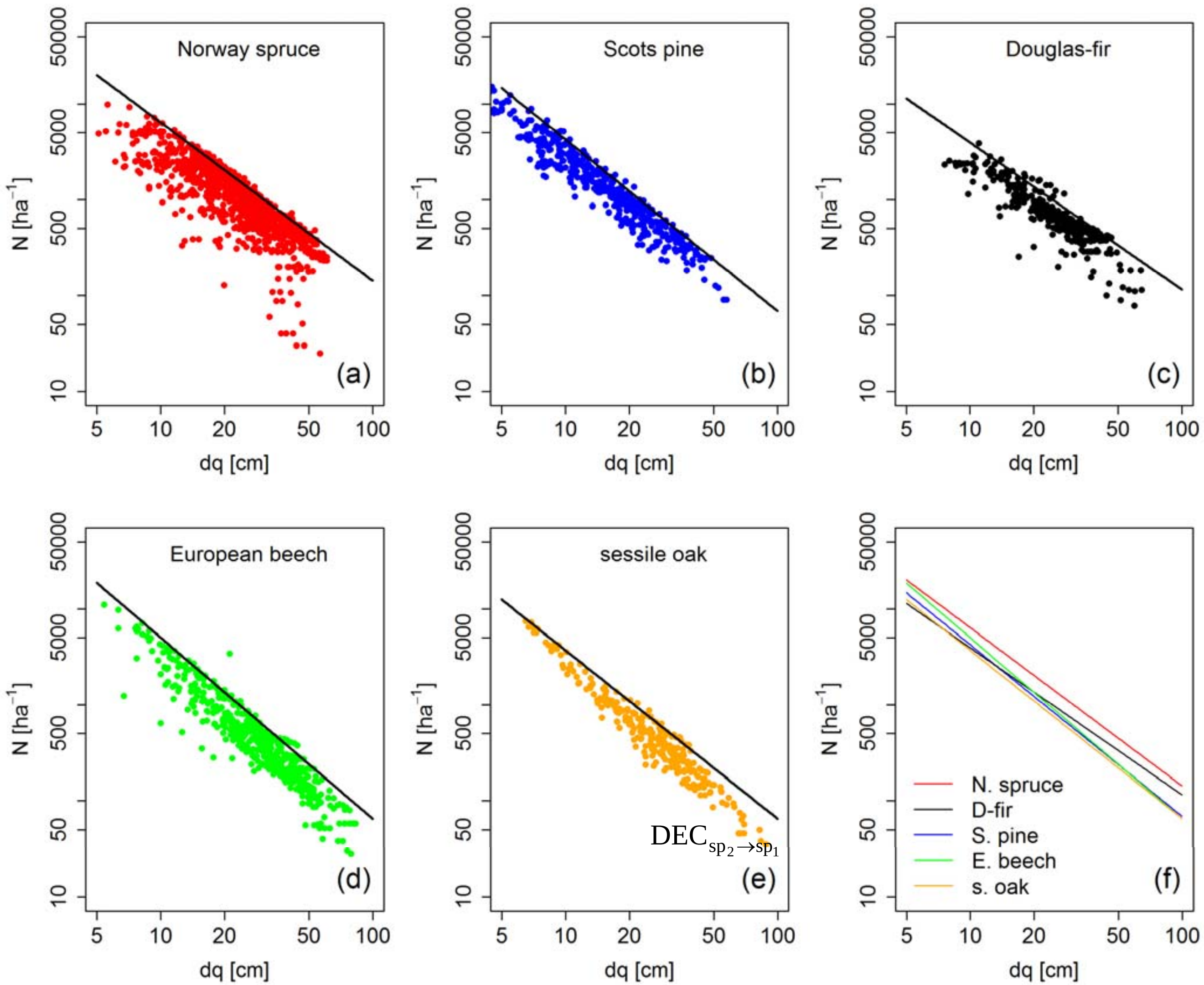
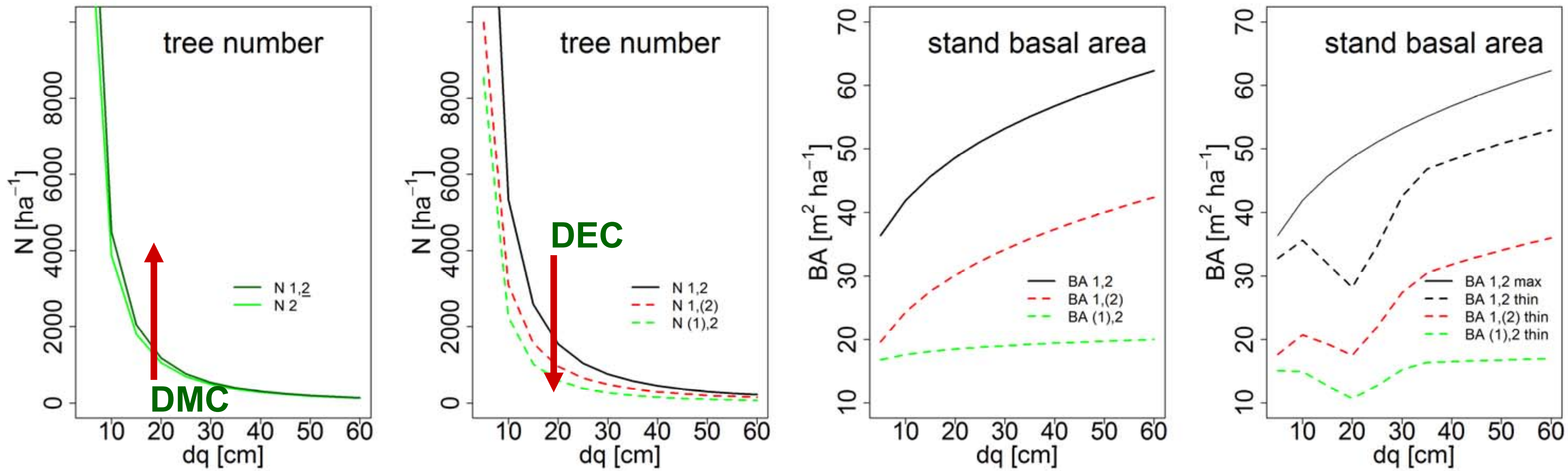
Problem 2: Different density, equivalence coefficients DEC

$N_1 \times DEC_{1 \to 2} = N_2$ $DEC_{1 \to 2} = SDImax_2 / SDImax_1$ $DEC = 0.30 - 1.80$



Application of DMC, DEC and density reduction



From max. tree number of reference species in monoculture to max tree number in mixture by DMC

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From tree number to stand basal area of sp.1 and2 area related mix 0.5:0.5

From max stand basal area to basal area of mixture area related mix 0.5:0.5

Formulas for mixing regulation with the Density equivalence coefficient

Species proportion of numbers of trees (m_{N1}, m_{N2}, where $m_{N1}+m_{N2}=1$)

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Species proportion by area (m_{A1}, m_{A2}, where $m_{A1}+m_{A2}=1$)

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$$N_{1,2} = N_{1,\underline{2}} \times (m_{A_1} \times DEC_{sp_2 \rightarrow sp_1} + m_{A_2})$$

Pretzsch and del Río (accepted)
Density regulation of mixed and mono-specific forest stands...Forestry

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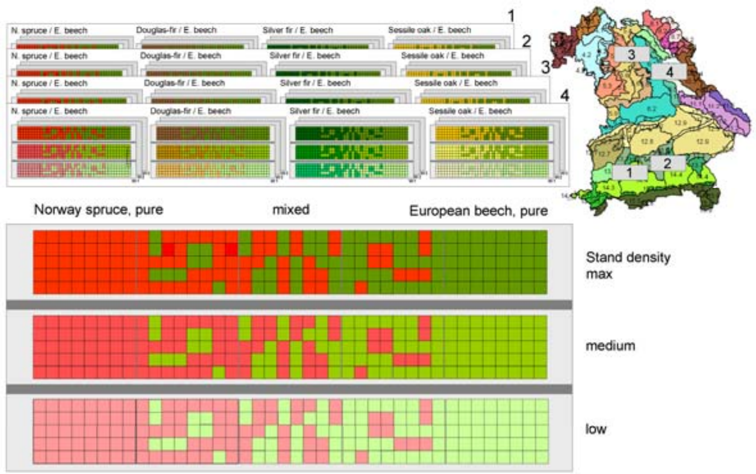
Perspective. Next steps

- Further tests and implementation of DMC, DEC
- Further quantitative formulation of silvicultural guidelines for mixed stands (crop tree selection and release, frequency of th.)
- Algorithmic formulation and integration into models and simulators
- Treatment concepts for long-term experimental plots

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Example of Density Equivalence Coefficients, DEC, for E. beech→N. spruce and E. beech →S. pine

d_q	d_q Norway spruce					
E. beech	10	20	25	30	40	50
10	***1.27***	0.41	0.28	0.21	0.13	0.09
20	4.70	***1.50***	1.04	0.77	0.48	0.33
25	7.16	2.28	***1.58***	1.17	0.73	0.50
30	10.10	3.22	2.23	***1.65***	1.03	0.71
40	17.39	5.54	3.83	2.84	***1.76***	1.22
50	26.49	8.44	5.84	4.32	2.69	***1.86***
d_q	d_q Scots pine					
E. beech	10	20	25	30	40	50
10	***0.85***	0.24	0.16	0.12	0.07	0.05
20	3.13	***0.91***	0.61	0.44	0.26	0.18
25	4.77	1.38	***0.93***	0.67	0.40	0.27
30	6.72	1.95	1.31	***0.94***	0.56	0.38
40	11.57	3.35	2.25	1.62	***0.97***	0.65
50	17.63	5.10	3.42	2.47	1.48	***0.99***