

## Effects of stand density on growth and form of 24-year old *Fraxinus excelsior* grown in Nelder experiments

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## Literature overview

### Recommended initial stockings

(pure stands, open field conditions, seedlings ha<sup>-1</sup>)

Author(s)	Year	Region	Stocking
Lanier et al.	1986	France	(400-) 1100
Kerr & Evans	1993	Great Britan	2500
Duflot / Armand	1995	France	(300-) 1200
Burschel & Huss	1997	Germany	2500-7000
Joyce et al.	1998	Ireland	3300
Claesssens	2002	Belgium	2500
Kerr	2003	Great Britan	>2500
Röhrig et al.	2006	Germany	(>3000-) 5000
Dobrowolska et al.	2007	Poland	4000-6000

> No comprehensive spacing trial published

## Research question

How much seedlings are needed to get a sufficient number of good quality trees (future crop trees) at the end of the self-tending phase?



## Study site

- warm, Atlantic climate: 10.5 °C, 950 (500) mm
- alluvial, decarbonized, sandy, and well drained soil
- slightly influenced by fluctuating groundwater table

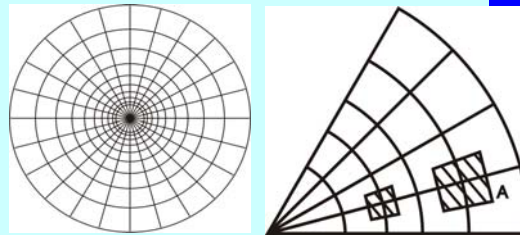
### > Good but not optimal

MAI 6-7 m<sup>3</sup> ha<sup>-1</sup> yr<sup>-1</sup>

- 3 complete Nelder circles (type 1a)
- established spring 1986 with 2-yr old nursery seedlings
- formative pruning and blanking fall 1986
- mechanical understory control and fencing

## Study design

No. of rings plot<sup>1</sup>: 8 (10)  
 No. of spokes plot<sup>1</sup>: 24  
 No. of trees plot<sup>1</sup>: 192 (240)



Spacing ring	Distance to plot center m	Growing space per seedling, A m <sup>2</sup>	Initial stocking seedlings ha <sup>-1</sup>
1 ( <i>guard</i> )	1.80	0.22	45,000
2	2.19	0.33	30,780
3	2.79	0.53	18,765
4	3.55	0.84	11,800
5	4.53	1.42	7,060
6	5.77	2.28	4,385
7	7.36	3.73	2,680
8	9.38	6.00	1,665
9	11.96	9.80	1,020
10 ( <i>guard</i> )	15.24	15.84	631

## Data collection

### All trees:

- mortality
- dbh
- height
  - total, up to first dead and first green branch
- crown class
  - dominant, codominant, intermediate, overtopped
- stem form (lower 6 m)
  - straight, buckled, crooked, deformed
- crown form
  - monopodial, steeply angled, forked, brushy

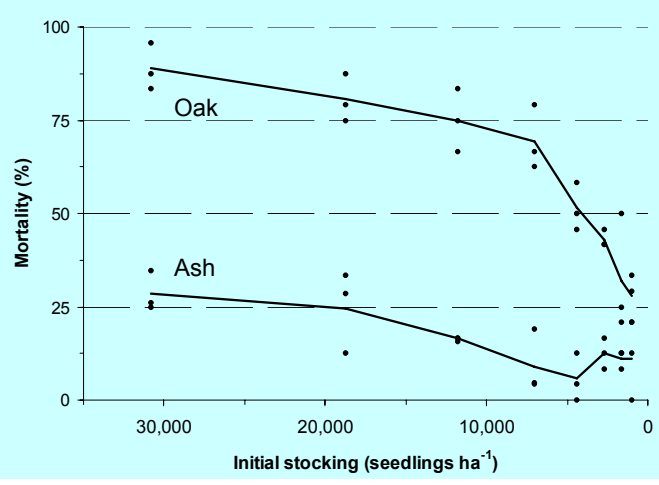
### 8 trees per ring and plot (randomly selected):

- branchiness along the lower trunk (6 m)
  - number of branches  $\geq$  2 cm in diameter
  - maximum diameter and angle (2-m sections)

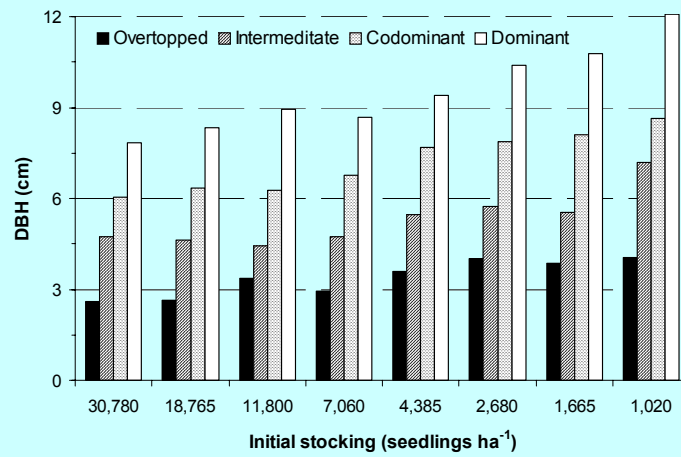
### Low mortality rate over the first 21 years

Spacing ring	Initial stocking (1986) seedlings ha <sup>-1</sup>	Actual stocking (2007) seedlings ha <sup>-1</sup>	Mortality (1986-2007) %	Total no. of trees (2007)
2	30,780	21,044	29	50
3	18,765	13,627	25	52
4	11,800	9,259	16	56
5	7,060	5,966	9	61
6	4,385	4,020	6	66
7	2,680	2,346	13	63
8	1,665	1,481	11	64
9	1,020	907	11	64

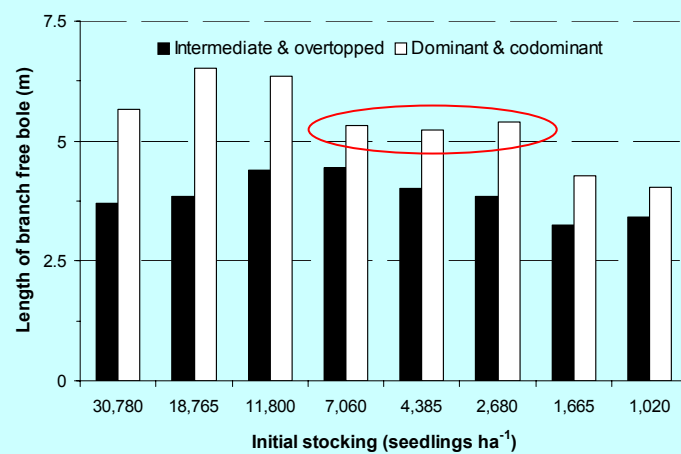
### Mortality over the first 21 years (cont.)

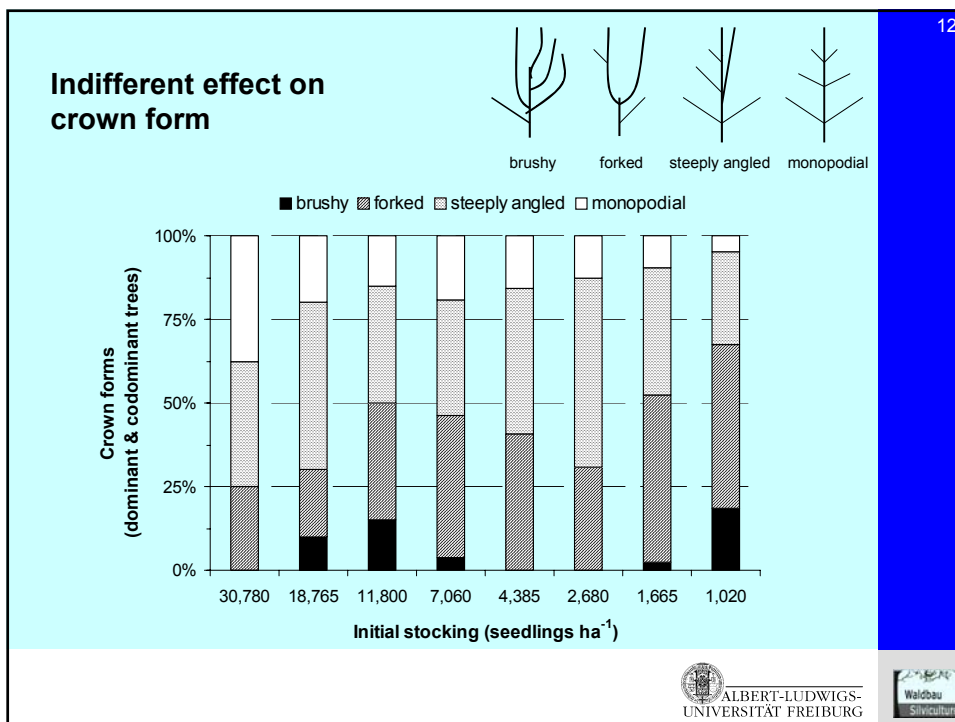
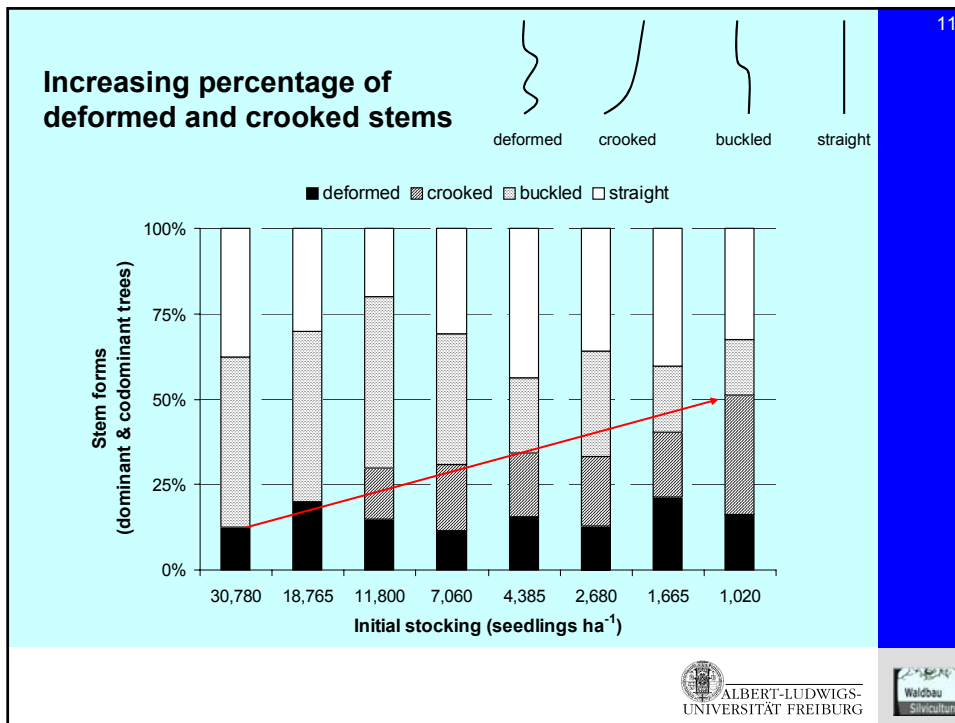


### Increasing DBH with decreasing stocking

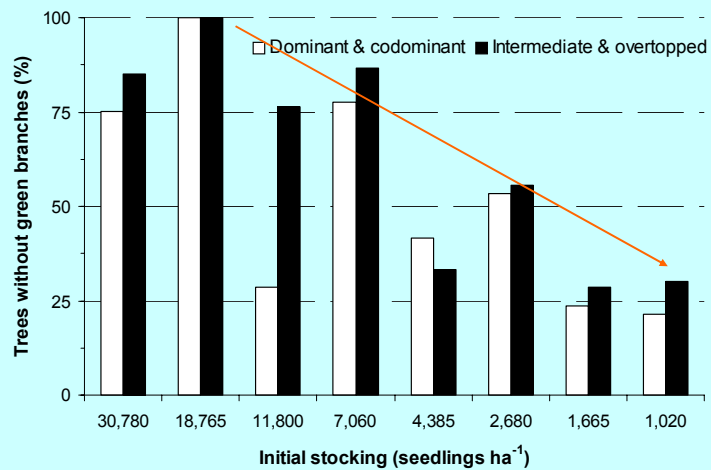


### „Stepwise“ decrease of branch free bole length





### Percentage of trees without green branches ( $\geq 2$ cm) (lower 6-m section)



### No. of dominant and codominant trees with good and very good quality

Very good: straight stem, monopodial crown, no green branches (lower 6 m)

Initial stocking	No. of stems ha <sup>-1</sup>		
	Very good	Good	Total
30,780	631		
18,765	262		
11,800	0		
7,060	230		
4,385	122		
2,680	14		
1,665	22		
1,020	4		

## No. of dominant and codominant trees with good and very good quality

Very good: straight stem, monopodial crown, no green branches (lower 6 m)

Good 1: straight stem, steeply angled crown, no green branches

Good 2: buckled stem, monopodial or branched crown, no green branches

Initial stocking	No. of stems ha <sup>-1</sup>		
	Very good	Good	Total
30,780	631	989	1620
18,765	262	1310	1572
11,800	0	742	742
7,060	230	804	1034
4,385	122	228	350
2,680	14	402	416
1,665	22	37	59
1,020	4	36	40

## Conclusions

- Growth parameters enhance significantly with decreasing initial stocking:  
> threshold of appr. 4400 seedling ha<sup>-1</sup> (CR, HDR)
- Rather indifferent effect on tree form and branchiness:  
> stem quality tends to degrade with decreasing initial stocking
- **Overly dense regeneration might retard stand development**
- **Initial stocking should not fall below 2500 seedlings ha<sup>-1</sup>**
- **Only slight differences between 2500 to 7000 seedlings ha<sup>-1</sup> for most of the analyzed parameters**



