FOX
FOrest Carbon Sink Optimization Model

Applicaton of FOX for Bosnia and Herzegovina: Modelling results and their interpretation

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Content

- Modelled forest areas
- Input data
- Plantations
- Coppice
- High forests
- Carbon prices vs. harvesting limits
- Conclusions

Which forests are modelled?

Forest land (ha) - Table 3.2	Economic	Non-Economic	Protected	Special purpose	Protective	Total
High forest	1,329,500	46,300	5,200	8,800	262,600	1,652,400
Coppice	843,200	158,700	1,600	2,400	246,300	1,252,200
Total forest	**2,172,700**	**205,000**	**6,800**	**11,200**	**508,900**	**2,904,600**
Shrubbery	52,700	41,100	0	100	36,700	130,600
Other forest area	3,300	3,100	0	100	2,600	9,100
Total FAO forest	**2,228,700**	**249,200**	**6,800**	**11,400**	**548,200**	**3,044,300**
Barren land	55,700	88,400	800	3,400	38,900	187,200
All forest and forest land	2,284,400	337,600	7,600	14,800	587,100	3,231,500

Source: FAO 2015 (partly based on NFI2 from year 2009)

Economic production and ownership (ha)	state	private	Total
High forest	1,063,400	266,100	1,329,500
Coppice	408,700	434,500	843,200
Total	1,472,100	700,600	2,172,700

Less active management, lack of data - most legal harvest comes from public forests

FOX data		
High forests	997,364	5 species
Coppice	446,416	3 species
Plantations	99,552	3 species
Total	**1,543,332**	

FOX data only for state owned forests with management plans, for main species, covering both entities

The relative importance of modelled forests

Forest area (ha)

FOX data		
High forests	997,364	5 species
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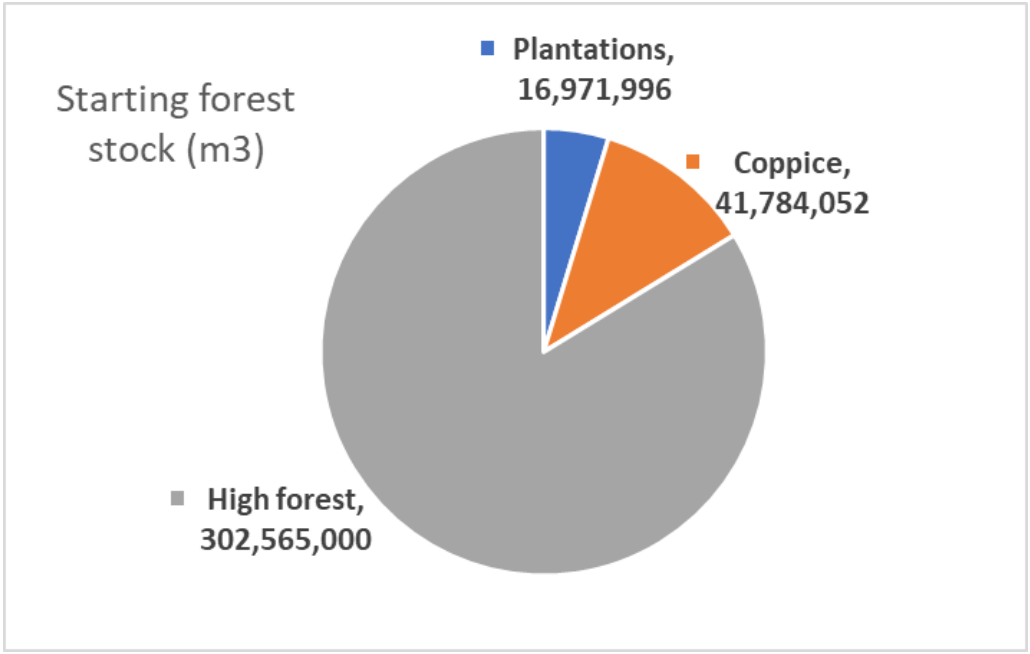


Converting forest data to suit FOX structure

Species

Diameter

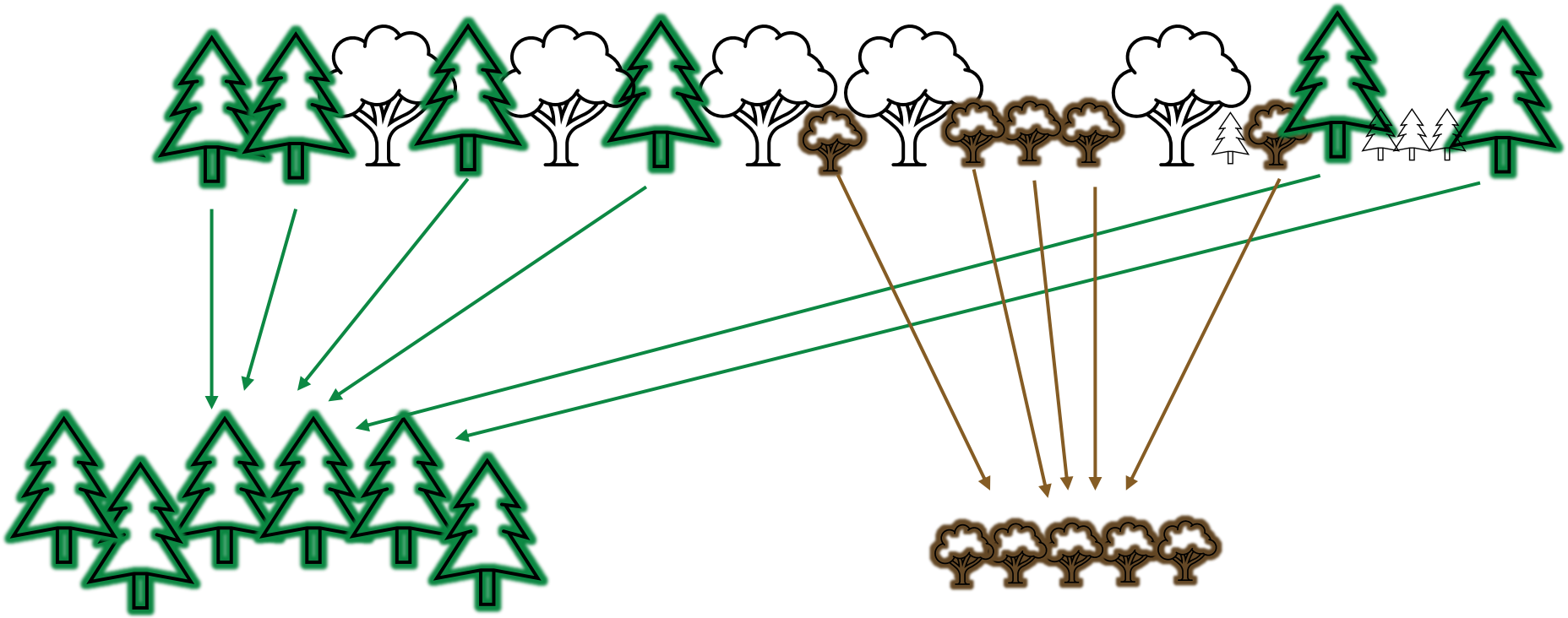
Number of trees / ha

→

Species

Age groups

m^3 / ha



Forests in the field:

uneven aged, mixed species

↓

„Virtual” forests in the model:

even aged, single species

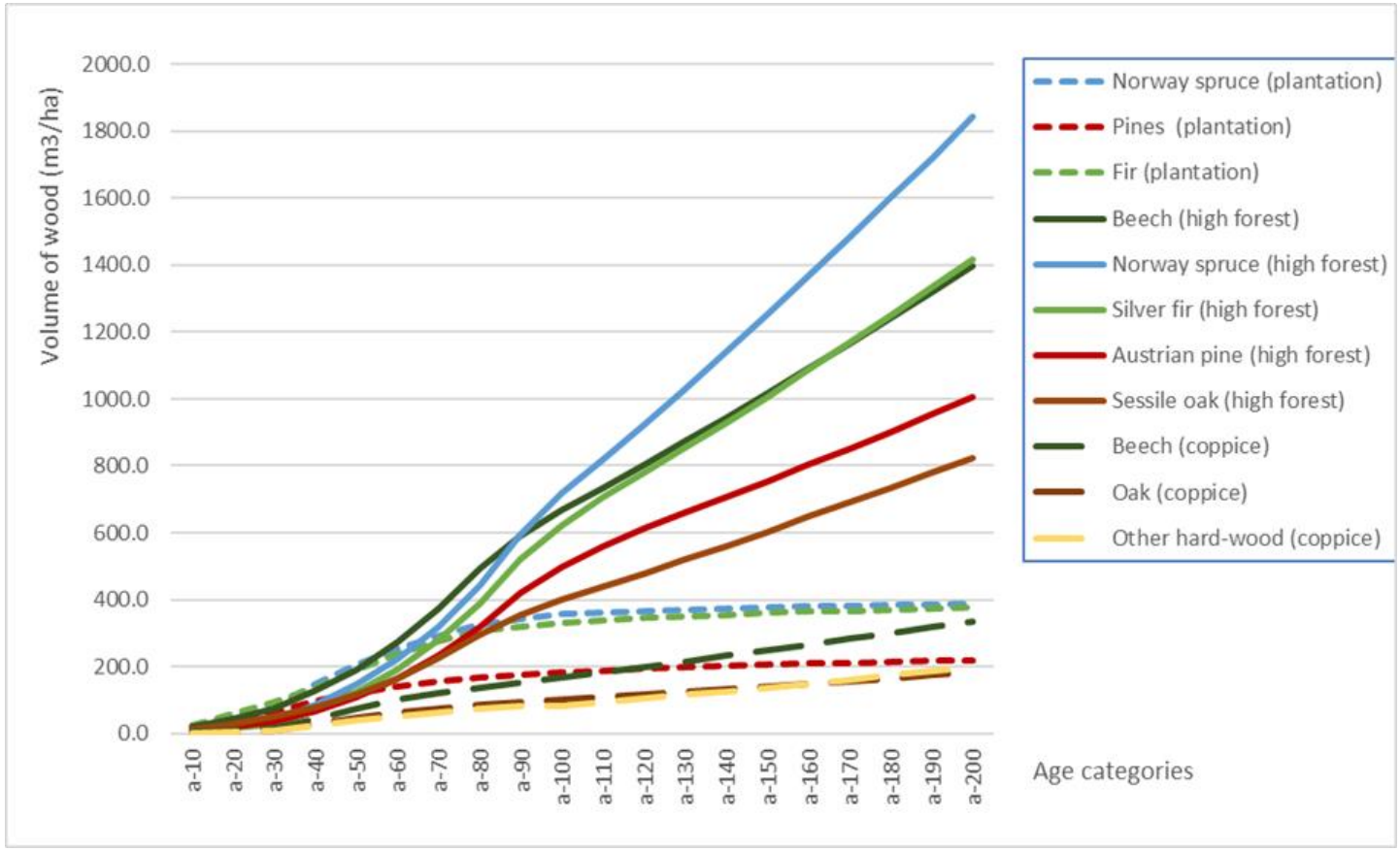
Model inputs: species specific age distribution (1000 hectares)

Age (years)	Plantation			High forest					Coppice		
	Norway spruce	Pines	Fir	Beech	Norway spruce	Silver fir	Austrian pine	Sessile oak	Beech	Oak	Other hard-wood
0-10	0.0	0.0	0.0	38.5	20.3	23.1	2.5	5.0	0.0	0.0	0.0
11-20	0.0	0.0	0.0	38.5	20.3	23.1	2.5	5.0	0.0	0.0	0.0
21-30	0.0	0.0	0.0	45.4	14.3	13.2	7.4	7.5	0.0	0.0	0.0
31-40	0.0	0.0	0.0	45.4	14.3	13.2	7.4	7.5	3.1	0.0	9.5
41-50	11.8	23.3	8.9	45.4	14.3	13.2	7.4	7.5	19.2	24.3	11.8
51-60	11.8	34.9	8.9	45.4	14.3	13.2	7.4	7.5	47.1	30.7	5.6
61-70	0.0	0.0	0.0	45.4	14.3	13.2	7.4	7.5	70.5	50.6	0.0
71-80	0.0	0.0	0.0	45.4	14.3	13.2	7.4	7.5	79.0	83.0	0.0
81-90	0.0	0.0	0.0	45.4	14.3	13.2	7.4	7.5	3.1	9.0	0.0
91-100	0.0	0.0	0.0	45.4	14.3	13.2	7.4	7.5	0.0	0.0	0.0
101-110	0.0	0.0	0.0	45.4	14.3	13.2	7.4	7.5	0.0	0.0	0.0
111-120	0.0	0.0	0.0	0.0	0.0	13.2	0.0	7.5	0.0	0.0	0.0
121-130	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.5	0.0	0.0	0.0
Total	**23.5**	**58.2**	**17.8**	**485.4**	**169.5**	**178.5**	**71.8**	**92.2**	**221.9**	**197.5**	**26.9**

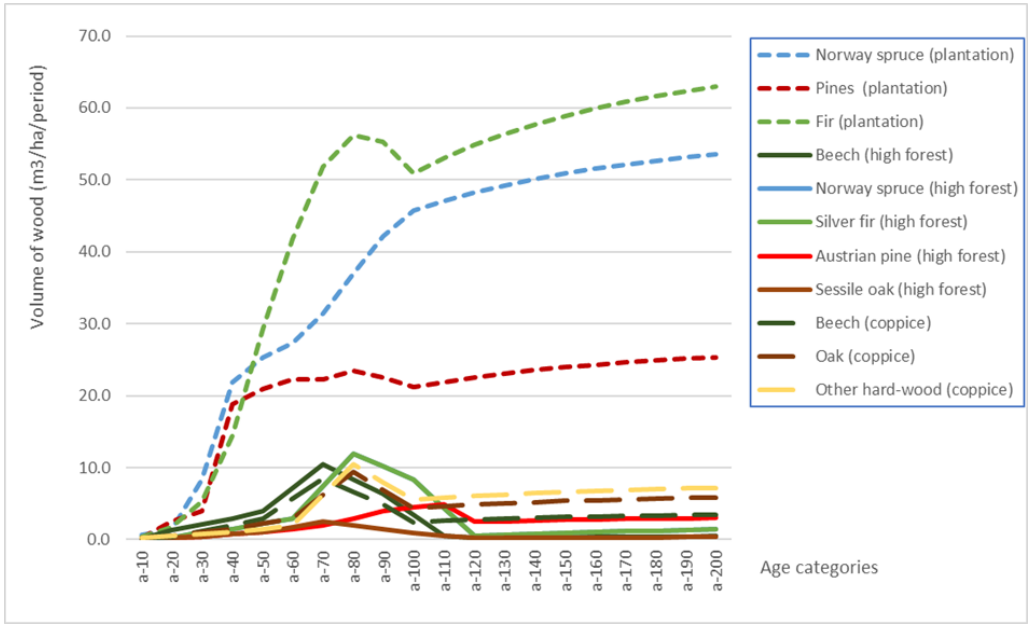
Representation of high forests by „virtual" age categories through calibration of the yield curves

Model inputs: Yield curves for main stands and thinning

Main stand (m^3/ha)



Thinning (m^3/ha/period)



1 modell period is 10 year long

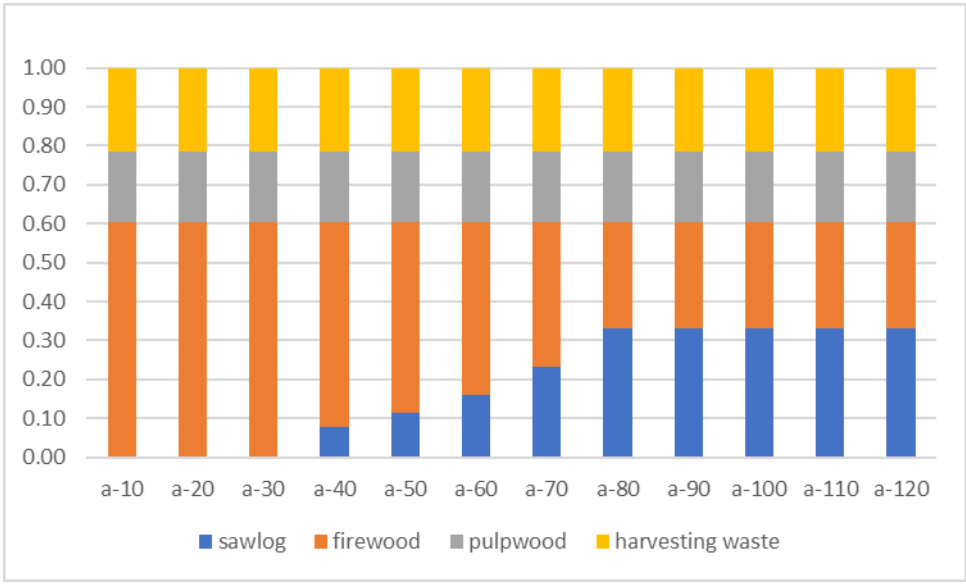
EFISCEN methodology to smooth the curve and generate missing pieces of data

Sortiments in harvested wood

Composition of timber at harvesting age

	sawlog	firewood	pulpwood	harvesting waste	harvesting age (years)
Norway spruce (plantation)	35%	0%	36%	29%	40
Pines (plantation)	35%	0%	36%	29%	40
Fir (plantation)	35%	0%	36%	29%	50
Beech (high forest)	33%	27%	18%	22%	80
Norway spruce (high forest)	62%	0%	10%	28%	80
Silver fir (high forest)	63%	0%	12%	25%	90
Austrian pine (high forest)	66%	0%	11%	23%	80
Sessile oak (high forest)	32%	28%	18%	22%	100
Beech (coppice)	6%	46%	22%	26%	50
Oak (coppice)	5%	47%	22%	26%	50
Other hard-wood (coppice)	0%	48%	26%	26%	50

The share of age-specific sortiments and harvesting waste for beech (high forest)



Costs and revenues

The average cost of cutting: 31 KM/m^3.

Average cost of reforestation: 4,000 KM/ha (relevant for plantation and coppice, 0 cost assumed for high forests)

Price of sortiments and weighted average values (KM/m^3):

	sawlog	firewood	pulpwood	harvesting waste	Starting volume of main stock (1000 m3)
Norway spruce (plantation)	160		52	0	5,395
Pines (plantation)	160		52	0	7,759
Fir (plantation)	160		52	0	3,818
Beech (high forest)	137	67	78	0	162,324
Norway spruce (high forest)	190		60	0	49,172
Silver fir (high forest)	177		60	0	49,672
Austrian pine (high forest)	150		60	0	17,884
Sessile oak (high forest)	280	78	78	0	23,512
Beech (coppice)	112	67	78	0	26,211
Oak (coppice)	250	67	70	0	14,588
Other hard-wood (coppice)		67	70	0	986
Average	**164**	**68**	**71**	**0**	
Average for plantation	160		52	0	
Average for high forest	164	68	71	0	
Average for coppice	161	67	75	0	

Real discount rate of 3%

Carbon content of harvested wood

Species or species group	Basic wood density t/m3	carbon fraction, t/t	carbon content t/m3
Quercus sp.	0.58	0.48	0.28
Quercus petraea	0.58	0.48	0.28
Fagus silvatica	0.58	0.48	0.28
Pinus silvestris	0.42	0.51	0.21
Pinus nigra	0.47	0.51	0.24
Picea abies	0.40	0.51	0.20
Abies alba	0.40	0.51	0.20

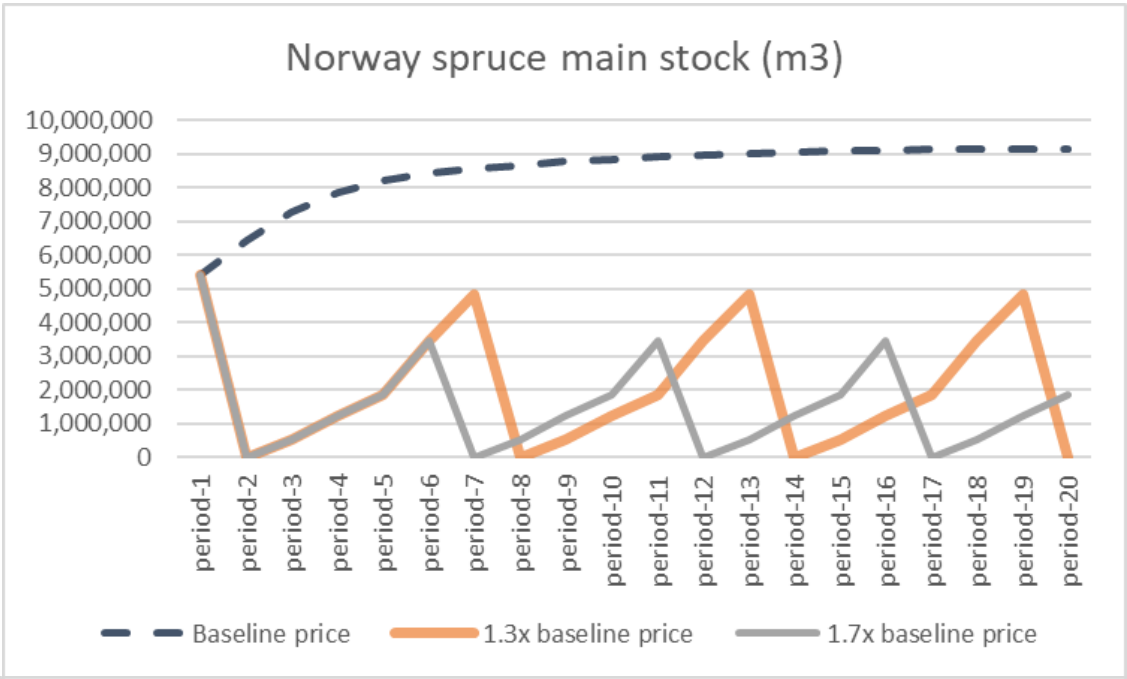
source: IPCC 2006 Guidelines, Chapter 4, Volume 4, Tables 4.3 and 4.14

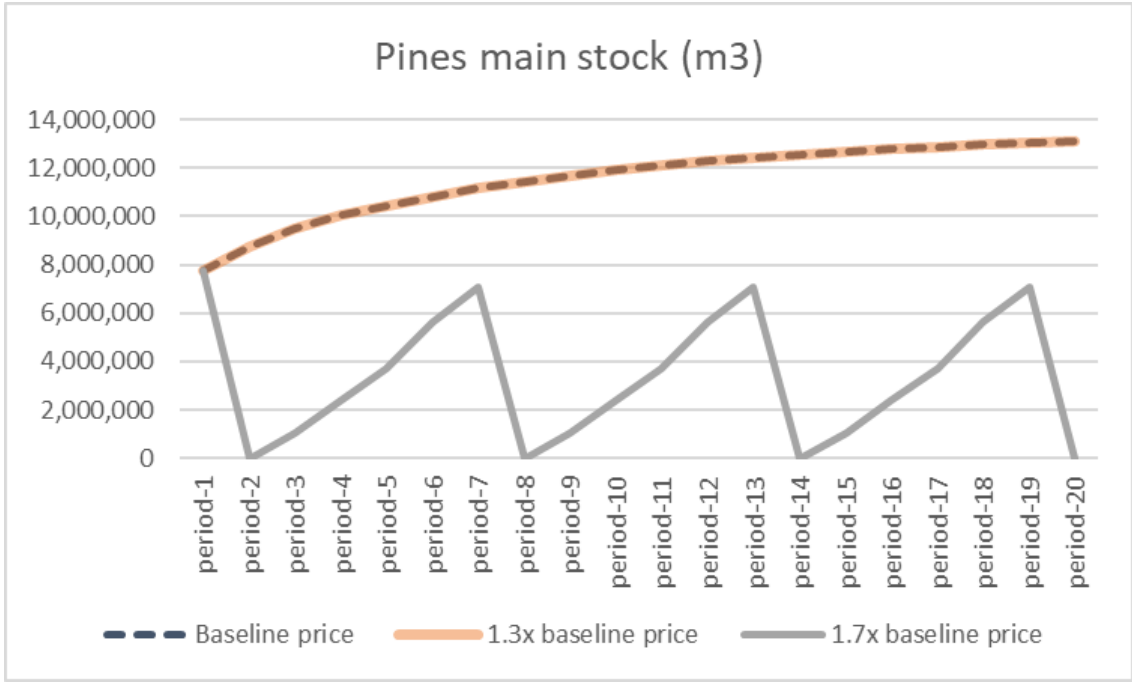
For the CO_2 equivalent, the carbon content must be multiplied by the mass of the molecule, 44/12

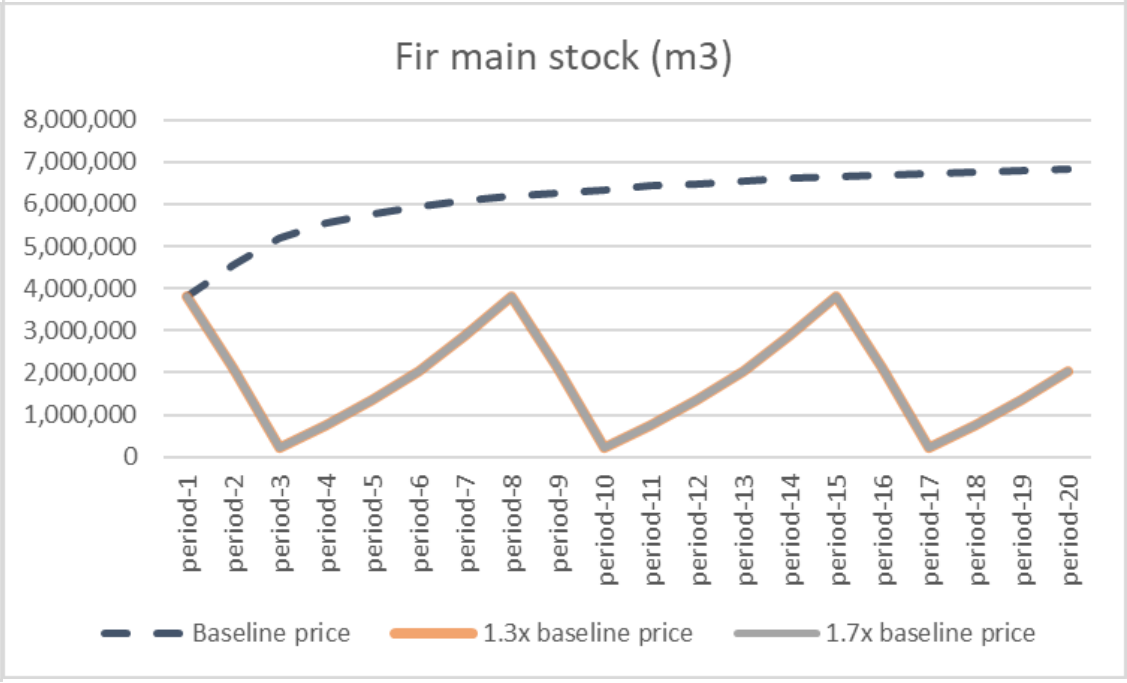
Plantations

Absence of significant harvest based on today's timber prices and forest management costs

Carbon payments would not make a difference





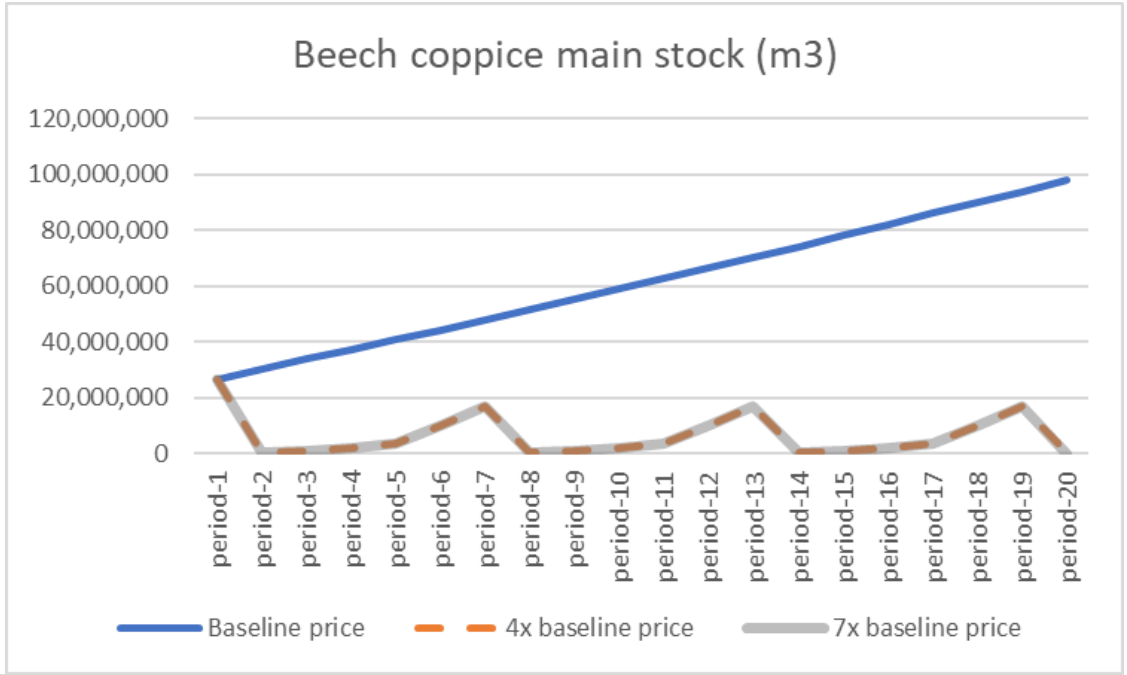


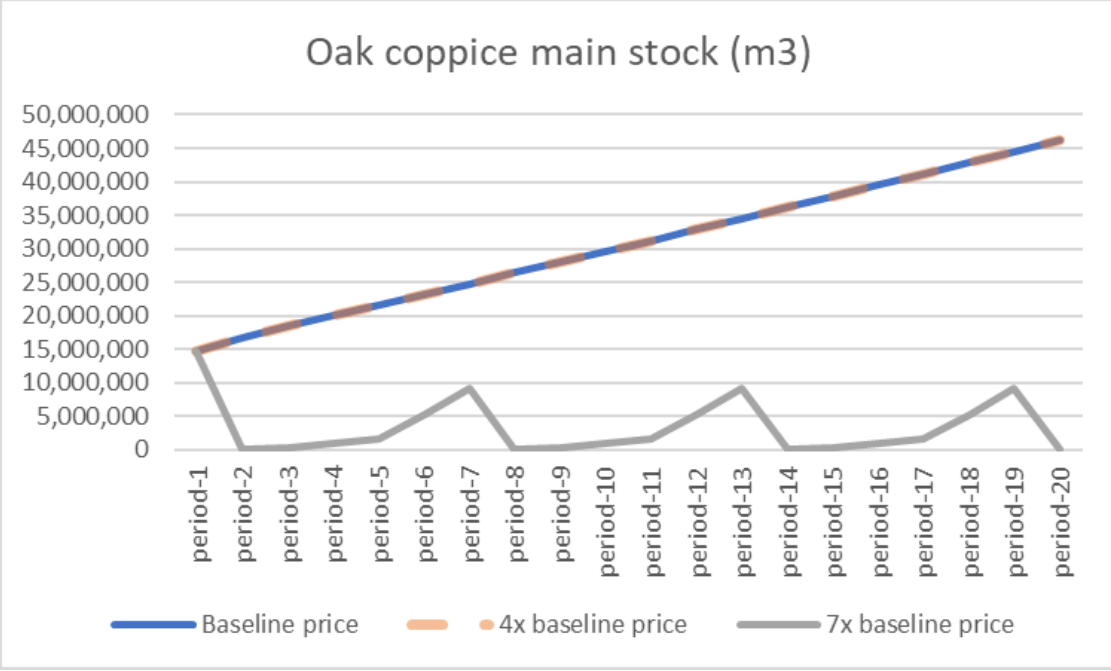
Coppice

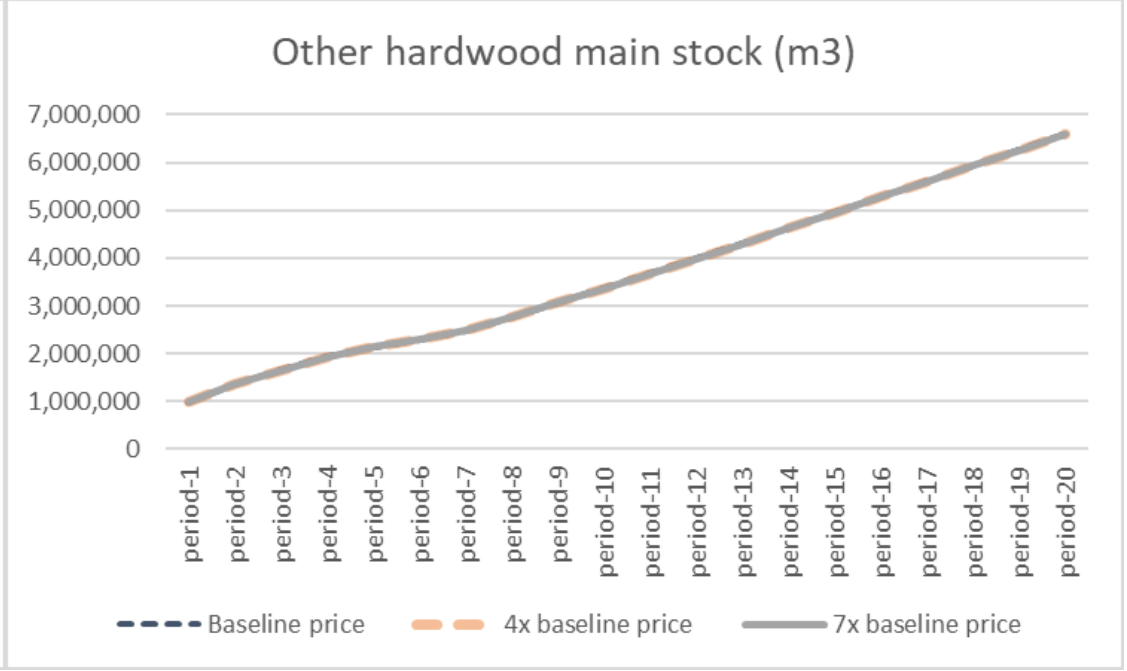
Absence of significant harvest based on today's timber prices and forest management costs

Carbon payments would not make a difference

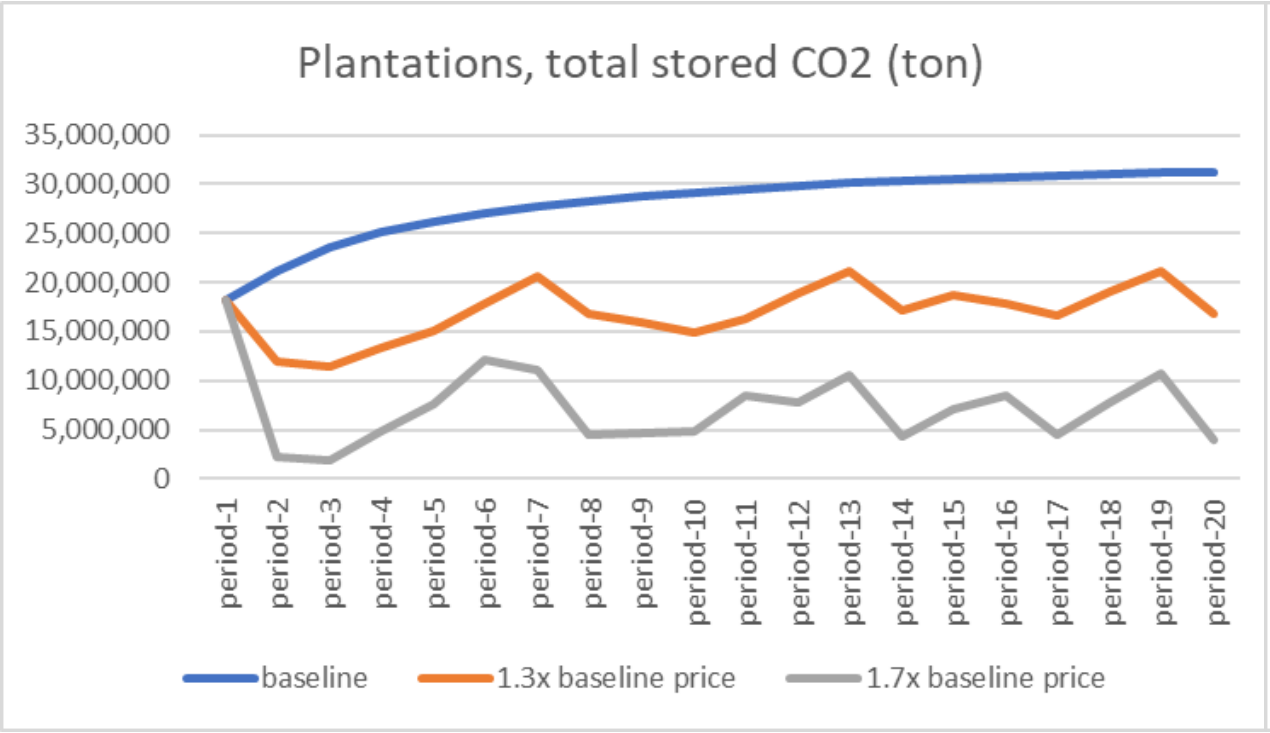
Selective cutting and natural regeneration (without reforestation costs) could act as a trigger for coppice management

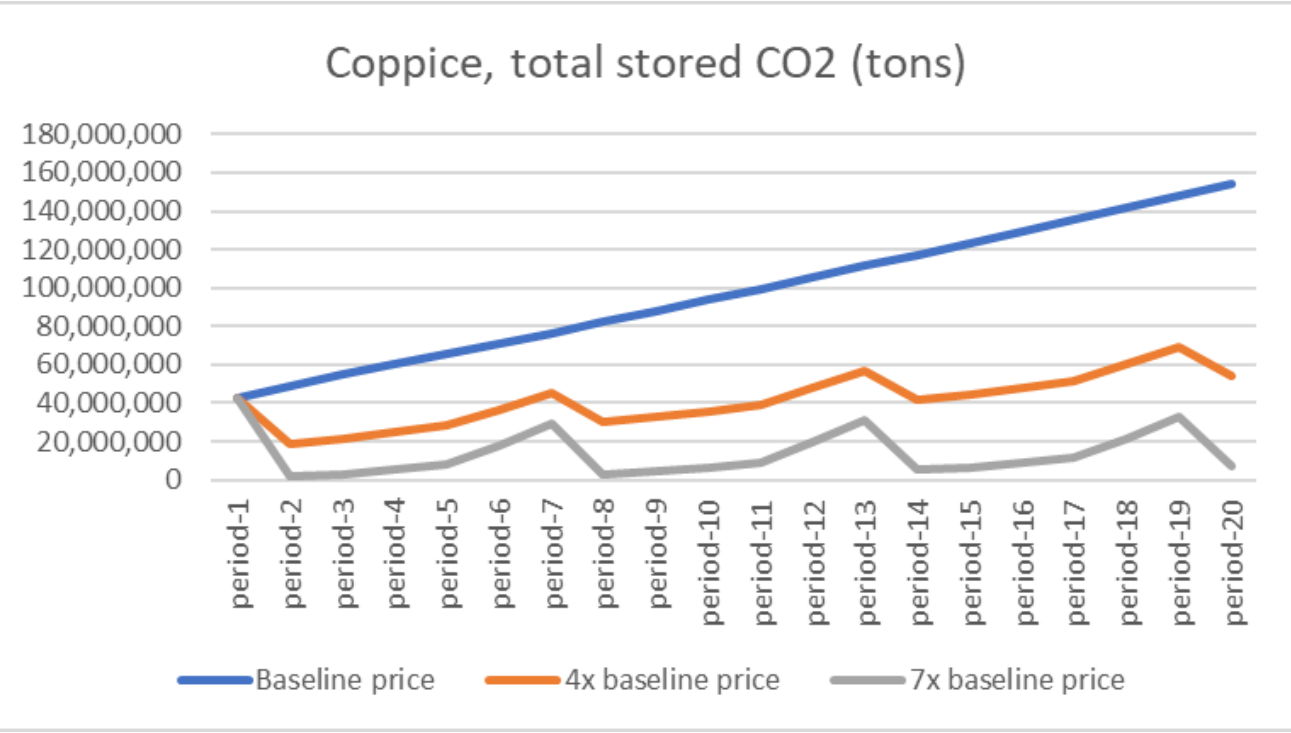






CO2 pathways at different timber price levels





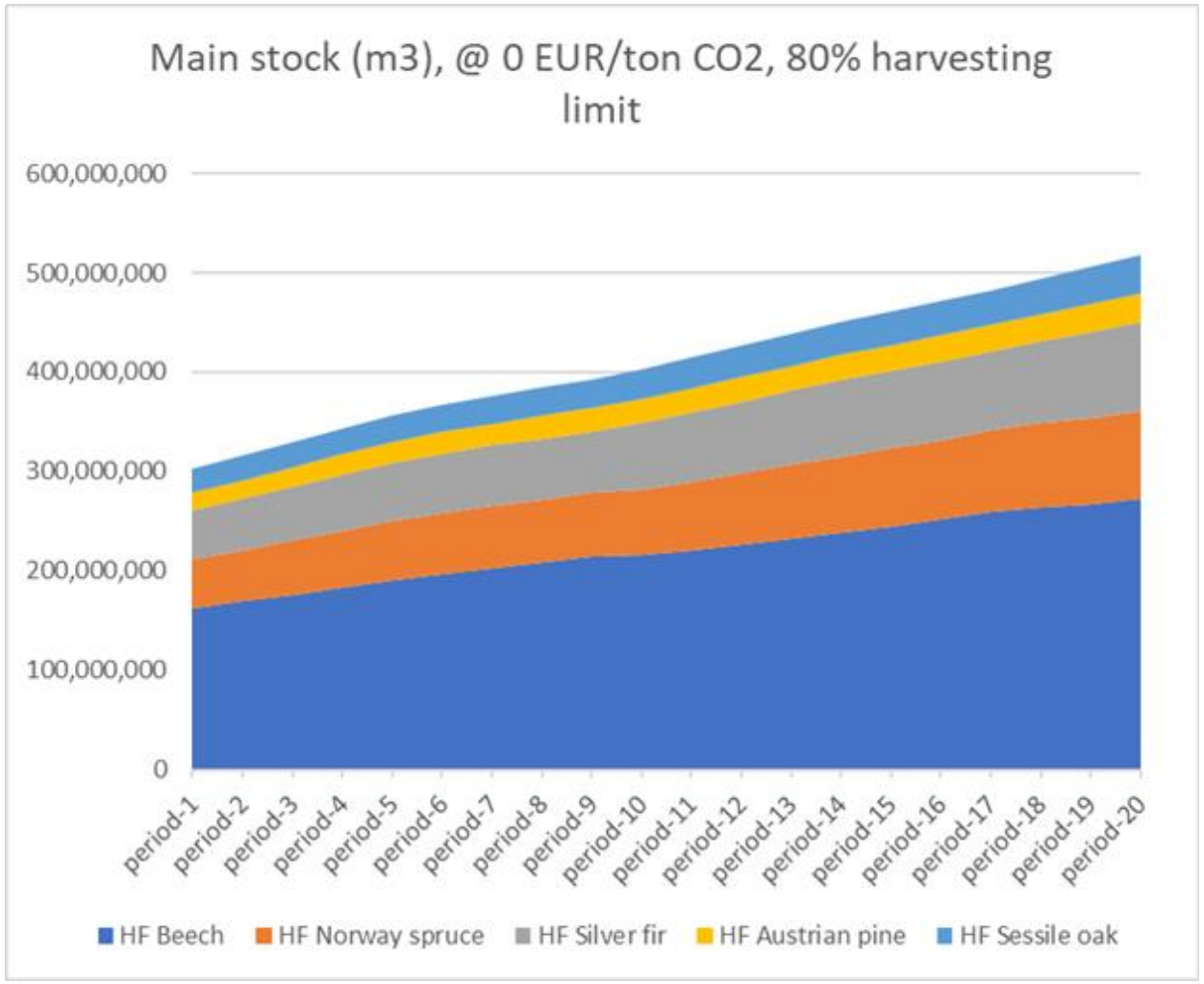
High forests

Two scenarios:

1. Current forest management: Harvest is limited to 80% of annual growth
2. Hypothetical scenario: only profit maximisation drives harvesting decision, without any regulatory limitation

How would the introduction of a carbon payment change the dynamics of these scenarios?

Current forest management, limiting harvest to 80% of annual growth

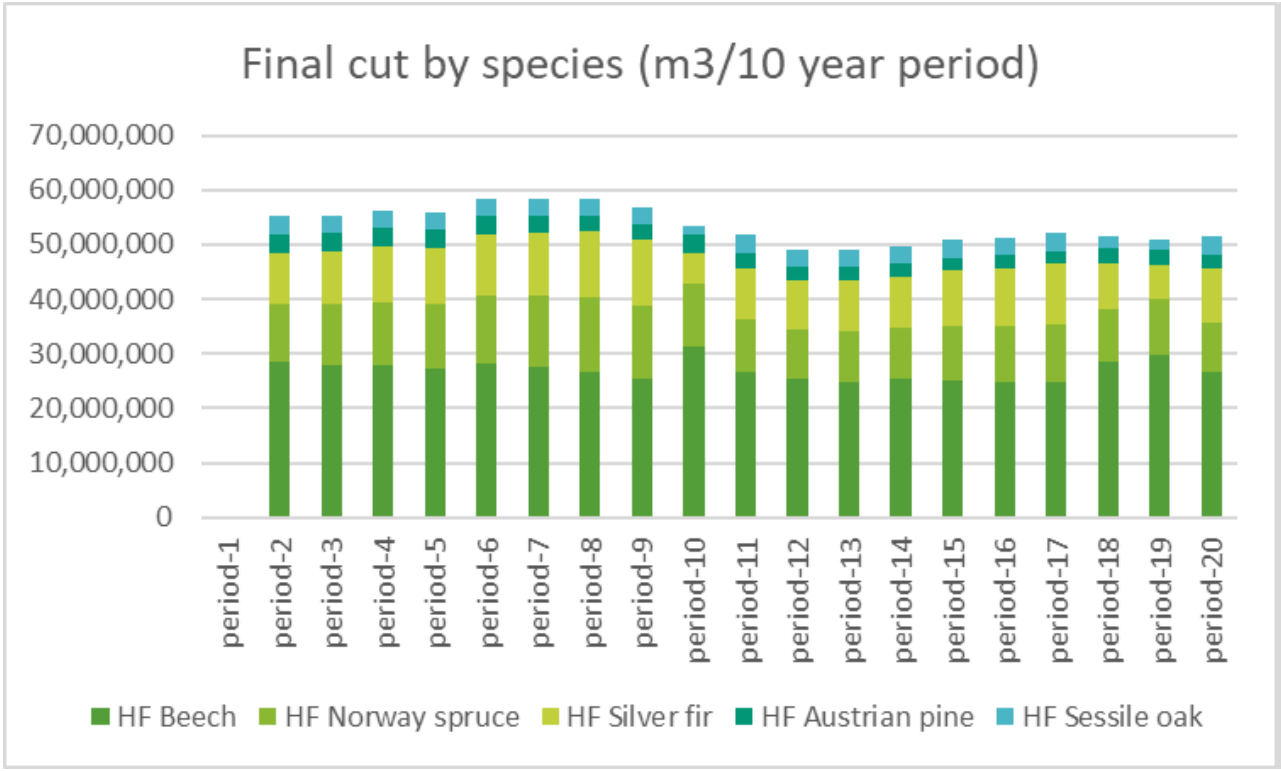


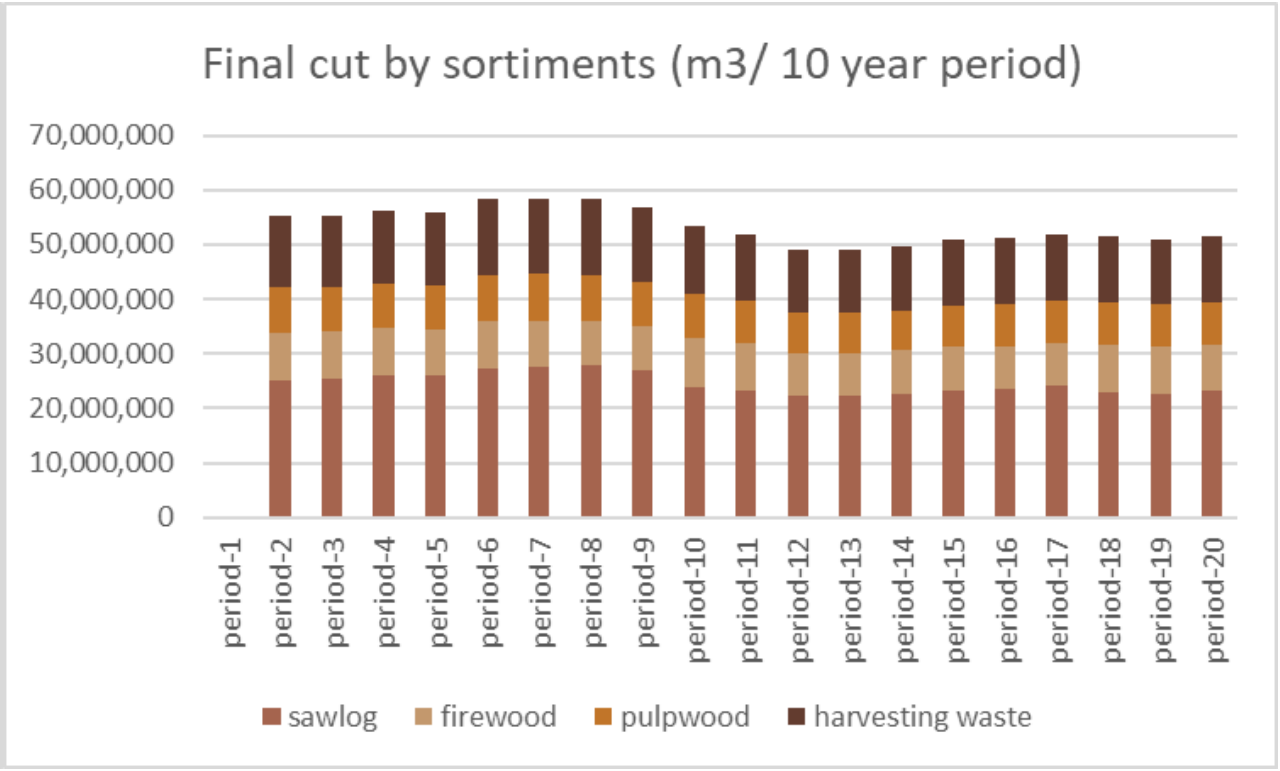
Constant growth of the volume of wood

Constant accumulation of CO_2

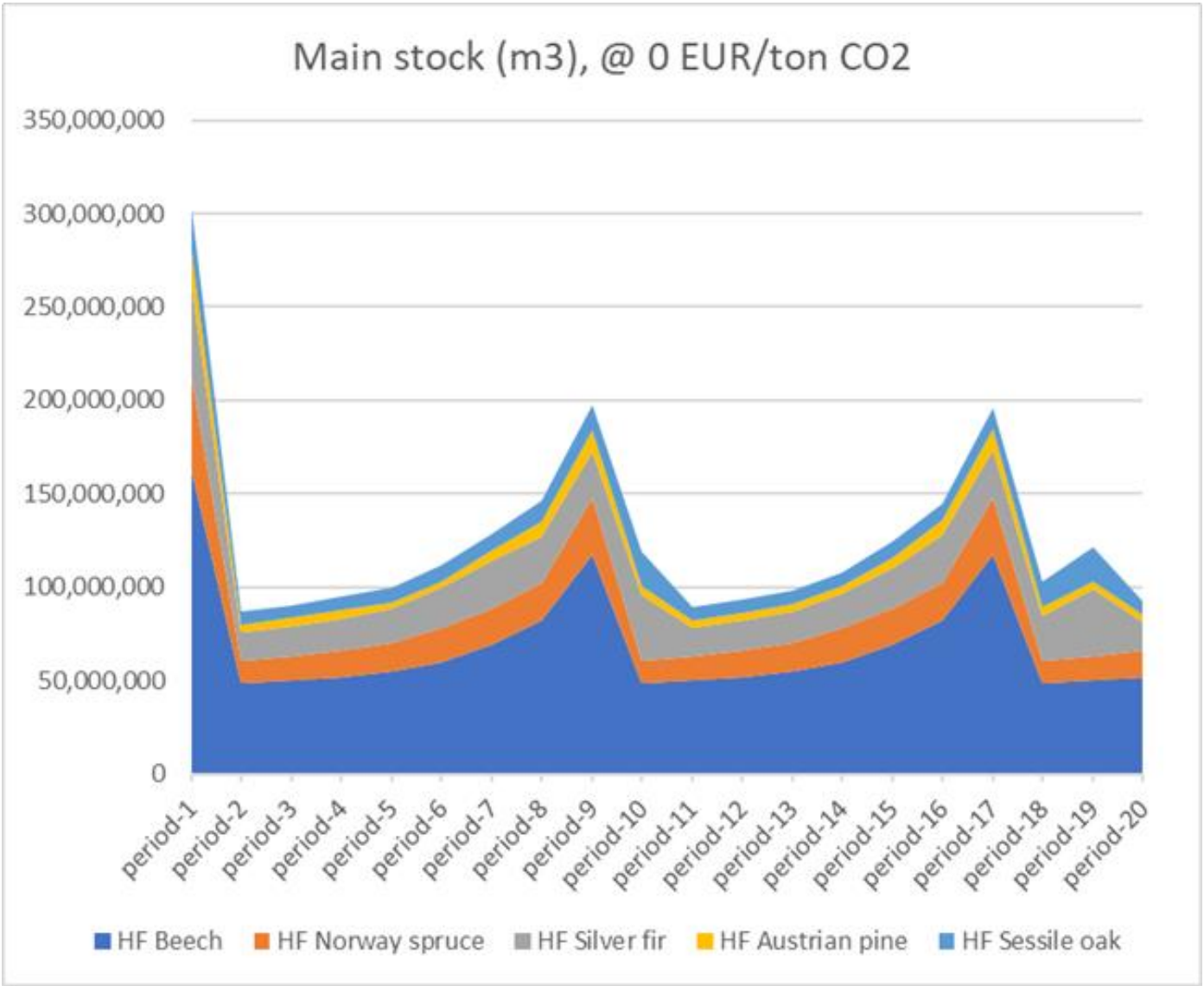
Current forest management, limiting harvest to 80% of annual growth

Sustainable harvest levels



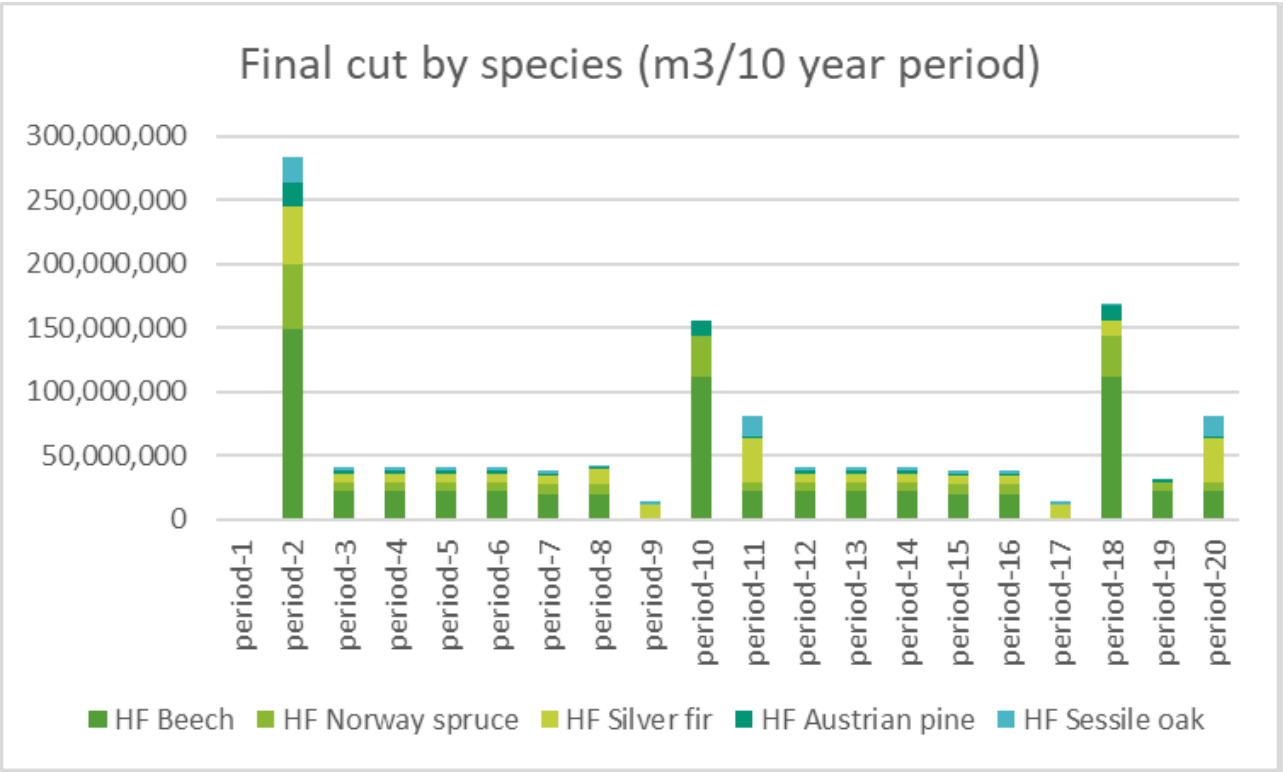


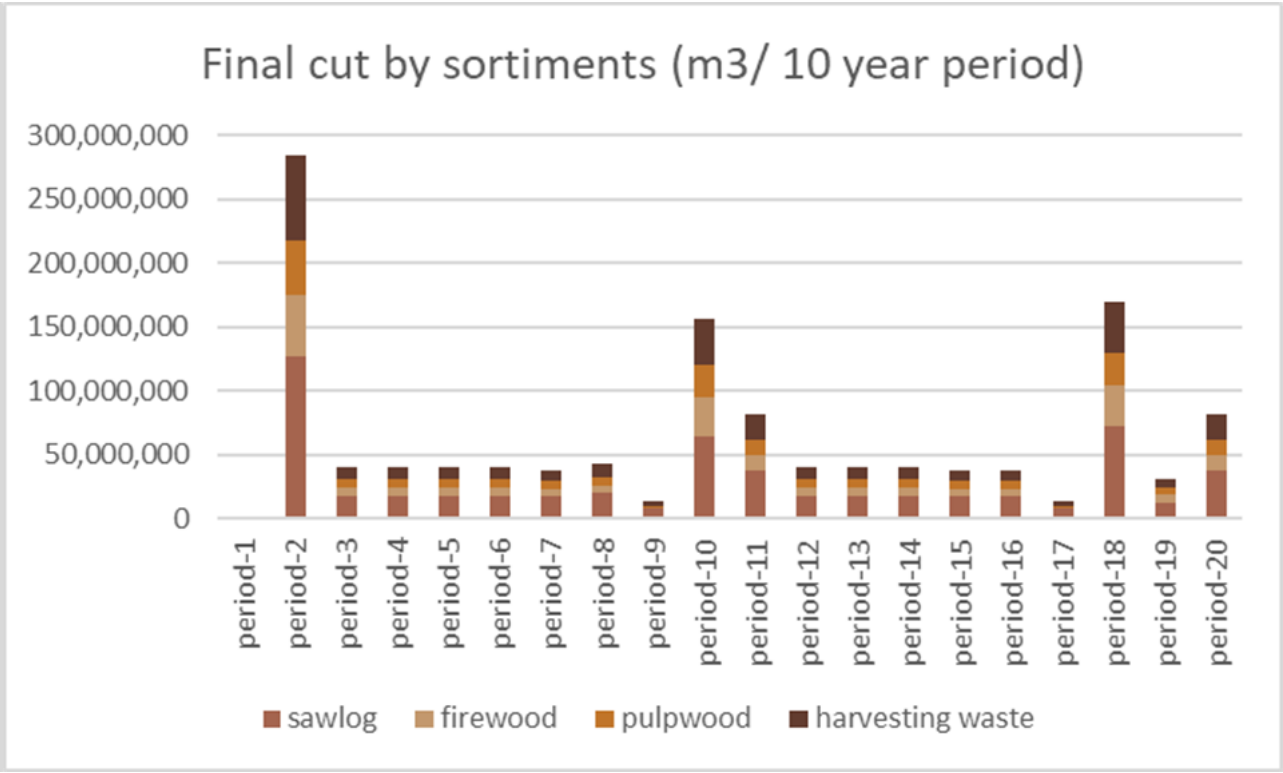
Hypothetical scenario: bio-economic relations drive the harvesting decision, no regulatory limit



- Sudden large harvest is driven purely by economic rationality
- Increased short term profit compared to the 80% harvesting limit scenario
- Loss of carbon stock over time
- The “80% limit” is ensuring sustainability in a very effective way

Hypothetical scenario: bio-economic relations drive the harvesting decision, no regulatory limit



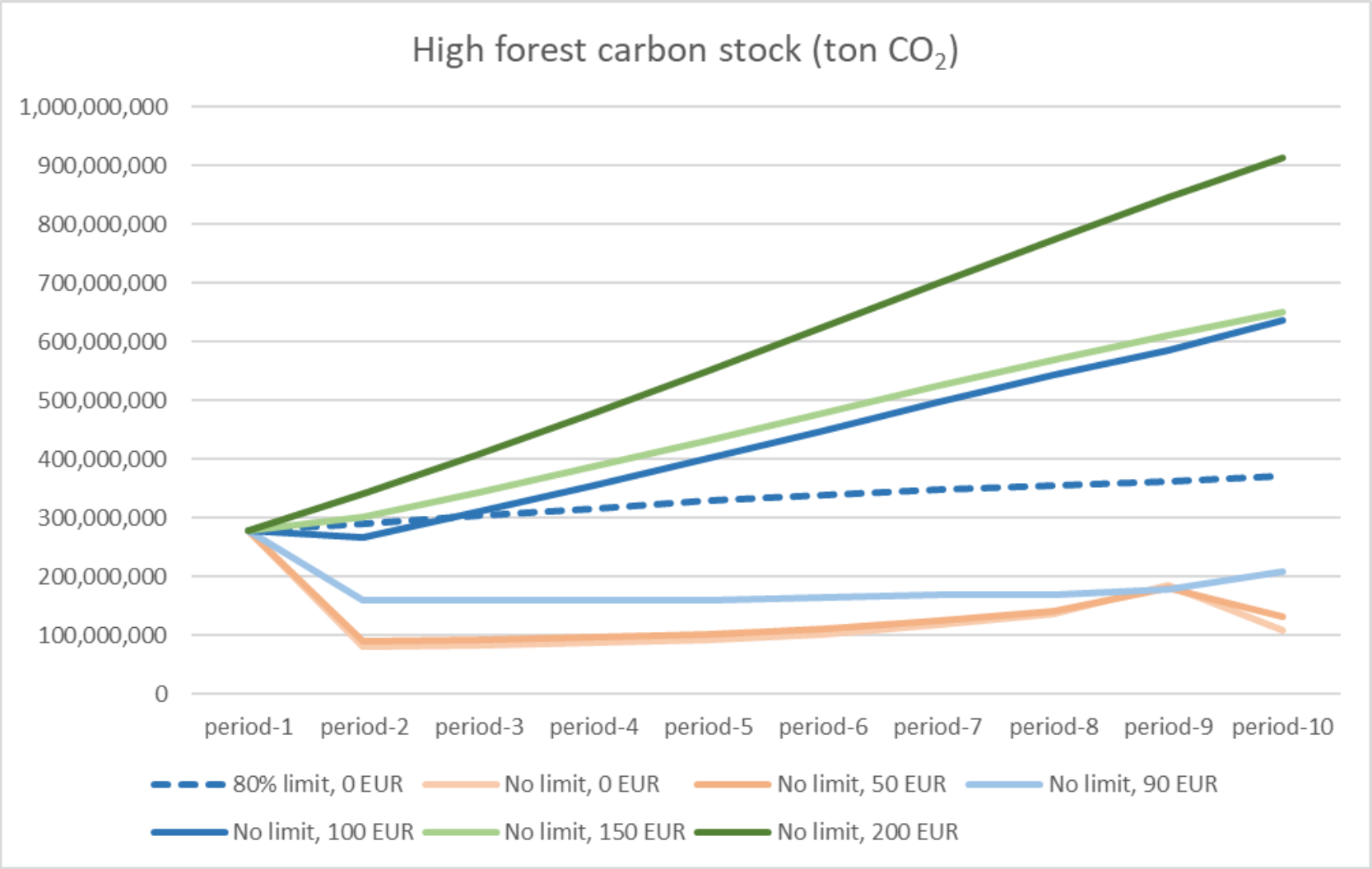


Net present value of harvested timber in 20 periods:

80% harvesting limit: 50.5 billion KM

No harvesting limit: 63.7 billion KM

Introduction of carbon payments for high forests



Carbon payments in EUR/ton CO_2

The current 80% harvesting rule has the same impact as a carbon payment of 90-100 EUR/ton CO_2 would

Carbon payments of around 100 EUR/ton CO_2 would result in the absence of harvest for beech and oak *

Carbon payments of around 180 EUR/ton CO_2 would result in the absence of harvest for Norway spruce, Silver fir and Austrian pine as well *

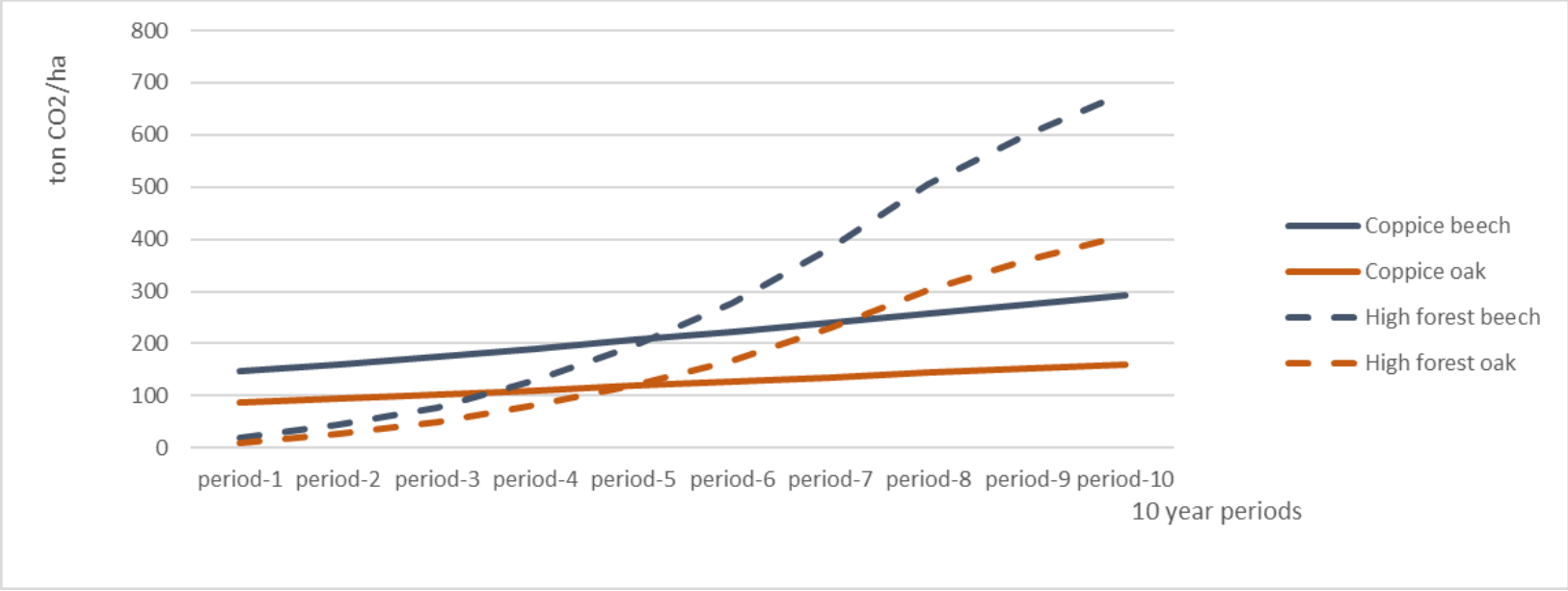
* it is more attractive to collect carbon payment than to cut and sell the timber

Transformation of coppice to high forest

Net cost of transformation per 1 hectare (KM/ha)		
	Beech	Oak
Cost of cutting	-4,490	-2,620
Revenue from sale of timber	7,537	5,006
Cost of reforestation	-4,000	-4,000
Lost revenue from thinning	-126	577
Total net cost	**-1,079**	**-1,037**

A subsidy of 1000+ KM/ha could elicit transformation of coppice forests to high forests, which will lead to more carbon sequestration:

250-390 ton/ha of additional CO_2 in 100 years



Key conclusions

Plantations and coppice:

- No meaningful harvest, CO_2 keeps accumulating at a slow rate
- Considerably higher timber prices would change this status quo
- Managed conversion of coppice to high forest could result in more CO_2 storage

High forests:

- Enforcement of current harvesting rules (80% limit) ensures sustainable forest management and it is equivalent to a powerful carbon sequestration policy
- Carbon payments of 100+ EUR/ton CO_2 would incentivize more sequestration (and lower harvests) than currently
- Changed management of beech and oak forests at and above 100 EUR/ton CO_2, for coniferous forests at around 180 EUR/ton CO_2

Key conclusions

More precise results are possible, they would require

- Further segmentation of forests (e.g. by productivity)
- Development of FOX toward continuous cover forest management

Further research ideas:

- Incorporating forest sequestration options into the national climate strategy (abatement cost curve)
- Integrated modelling of Central and South East European forests and timber markets
- The impact of climate change on BiH forests

Thank you for your attention!

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