METSIEN TALOUDELLISESTI KANNATTAVA KÄYTTÖ HIILENSIDONNASSA: METSIENKÄSITTELYN KEINOT JA KUSTANNUSTASO

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Objectives of the research project

To provide information for climate strategy and for planning forest management practices on

- **the costs and potential of carbon sequestration**
  - **depending on**
    - **initial state of forests**
    - **economic factors**
- **where and how to implement**
  - **which forests included / where to increase sequestration**
  - **changes in forest management**
  - **policy instruments**
- **impacts on forestry and timber supply**

Topic of this presentation

- So far, impacts of carbon payments on optimal silviculture (mainly on rotation length) have been analysed with given price of carbon

- We provide preliminary results for costs of carbon sequestration for existing forests in Finland

- Special attention is given to evaluating costs for stands of different ages

Laskelmien luonteesta

- **Taloudellisen ja biologisen tarkastelun yhdistäminen**

- **Verrattuna ekologiseen malliin voidaan tarkastella**
  - ✓**mitä hiilen sidonnan lisääminen maksaa eli paljonko hiiltä kannattaa sitoa**
  - ✓**mitkä metsänhoidon keinot kustannustehokkaimpia**
  - ✓**paljonko hiiltä saadaan sidottua tietyllä korvaustasolla**

- **Optimointi vs. simulointi**

- **Lähinnä tasapainotilojen vertailua. Myös aikauria.**

- **Diskonttaus**

Model

- Forest owner maximizes discounted net returns over an infinite time horizon
- Stand level model; SMA software
- MELA based growth models

Carbon sequestration in the model:

a) joint production of timber and carbon sequestration: maximizing the total discounted net returns from both timber and carbon revenues
b) increase in carbon sequestered obtained by fixing the average standing volume (presented here)

Hiilensidonta mallissa

- **SMA sisältää runkopuun (m3/ha).**
- **Muutetaan hiileksi vakiokertoimilla:**
  - **toistaiseksi käytetty: mänty 0.309 t C/m3, kuusi 0.3715 t C/m3**
  - **kertoimet päivitetään Lehtonen et al mukaisiksi**
- **Maaperän hiili puuttuu SMA-ohjelmistosta**

Optimizations

Increase in carbon sequestration obtained by increasing average standing volume by 20 or 40 m3/ha (23 or 45 t CO_2/ha) during the rotation period

Forest management options: rotation length, intensity and timing of thinnings

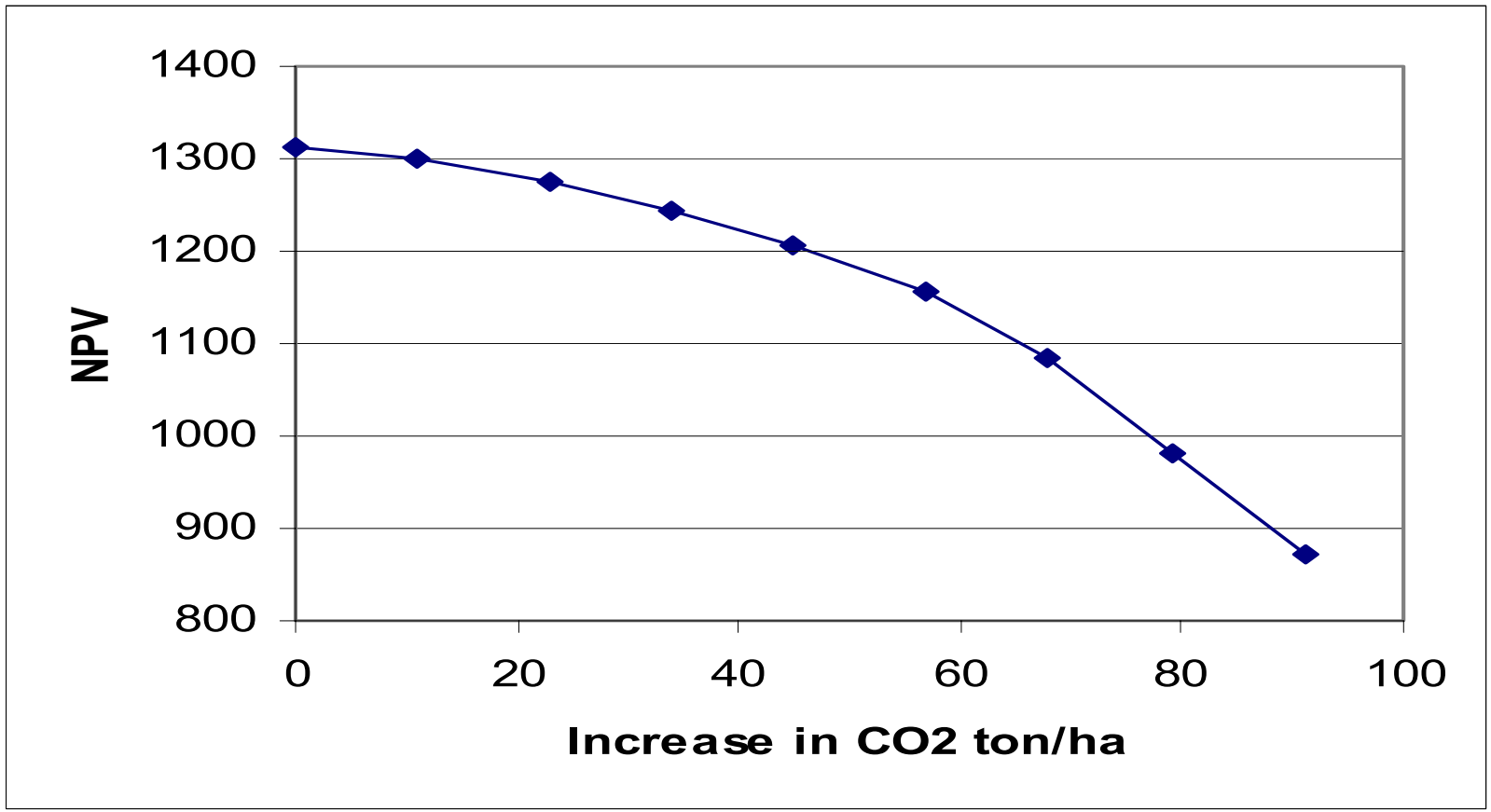
<u>Starting from bare land</u>

- **15 Scots pine stands from Southern and Central Finland**

<u>Starting from various stand ages</u>

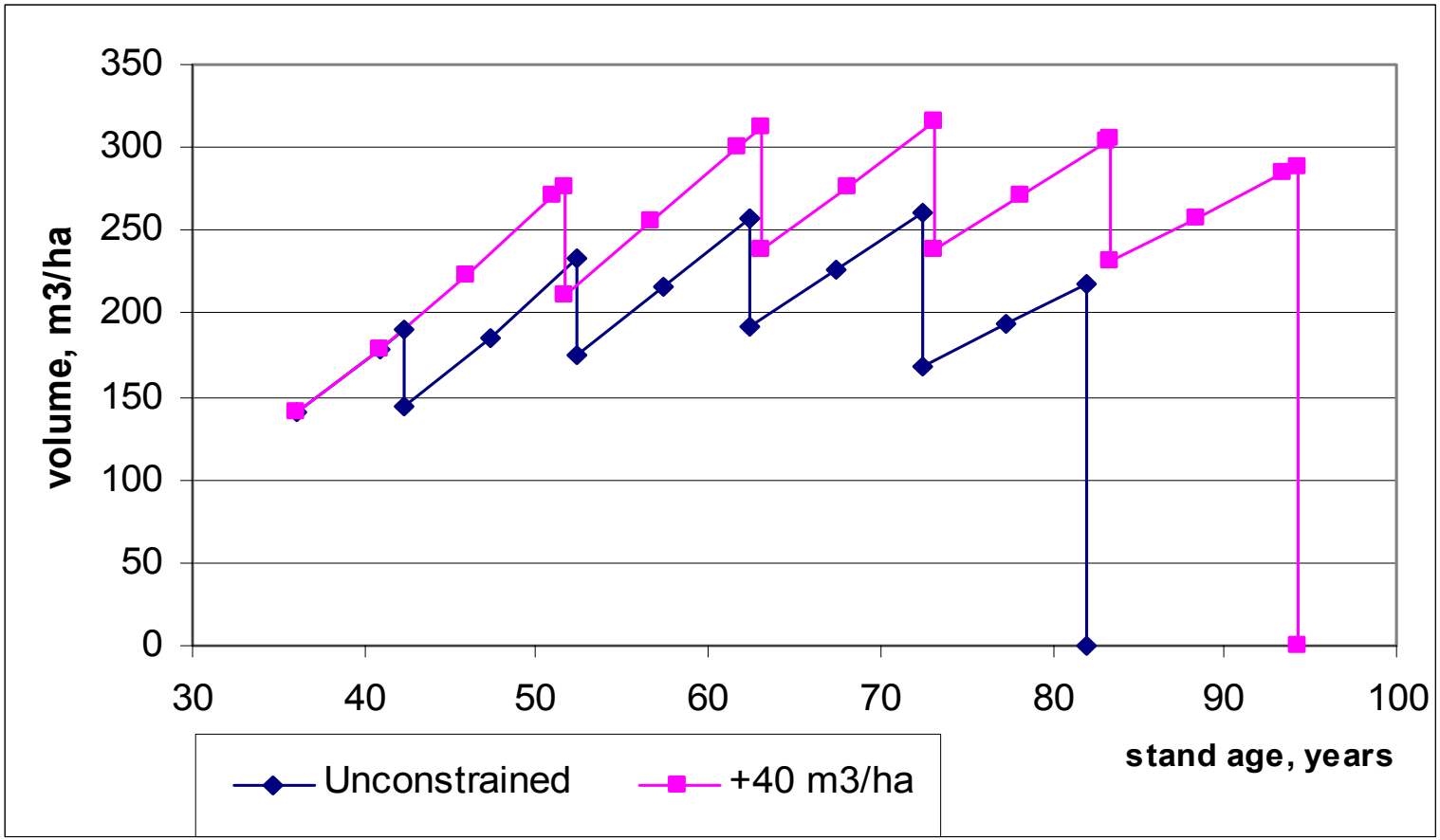
- **24-36, 50 and 70 years**
- **4 Scots pine stands from Southern and Central Finland**
- **state of the stand in various ages obtained by simulating the development of stand according to silvicultural recommendations of Tapio**

Production possibilities frontier (plot 34)



The tradeoff between the two objectives, namely timber production and carbon sequestration, can be described through production possibilities frontier analysis. The ppf of net present value of timber production and carbon sequestration for plot 34 is represented. Increasing carbon sequestration through the additional constraint reduces NPV.

Impacts on optimal silviculture (plot 4)



Korotettaessa keskitilavuutta 40m3/ha kiertoajan aikana (vastaa 45 t CO2/ha) harvennukset viivästyvät noin 10 vuodella ja kiertoaika pitenee 12 v.

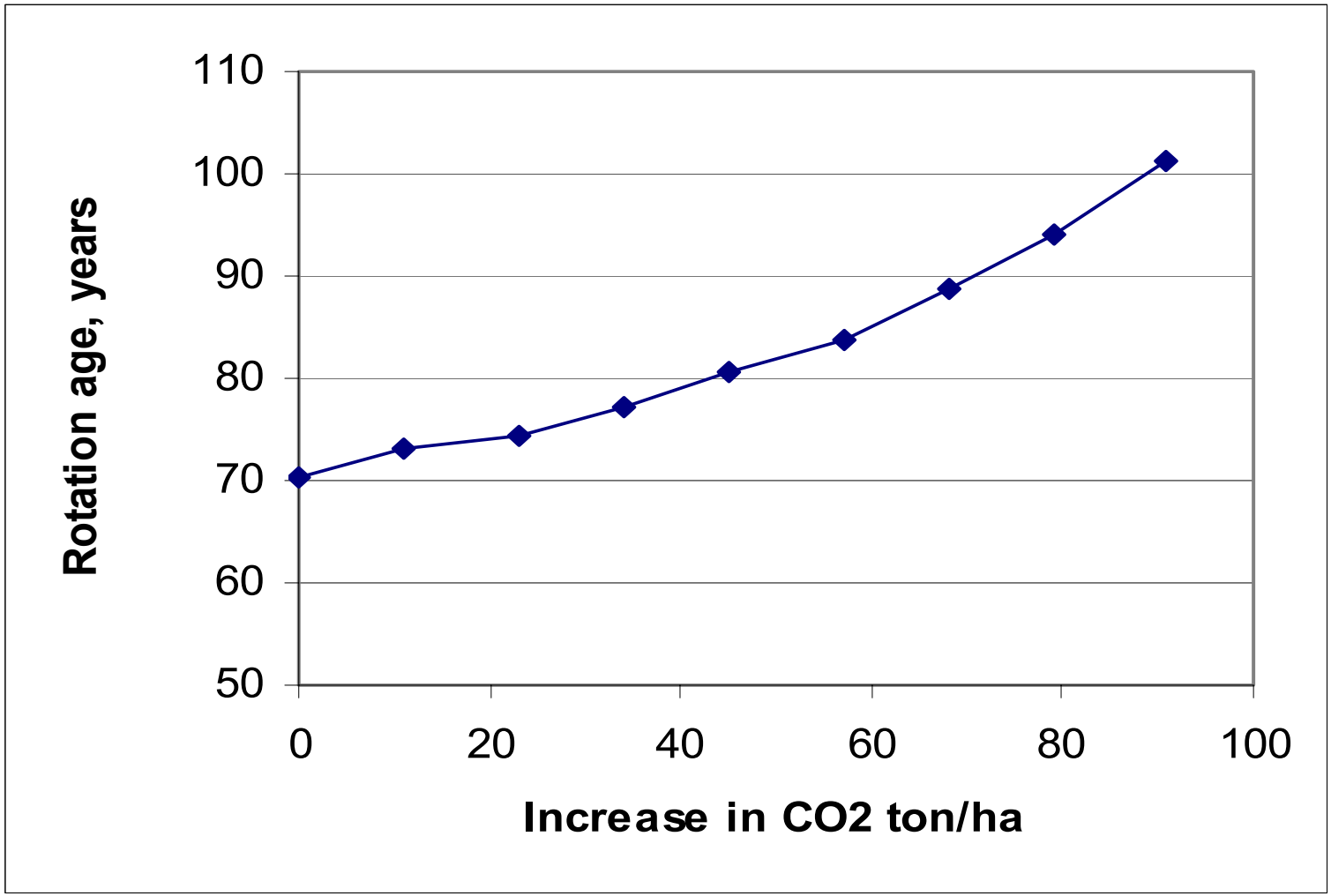
Harvennukset vs. kiertoaika

- **Harvennukset kustannustehokkaampi keino nostaa hiilensidontaa kuin kiertoajan pidentäminen.**

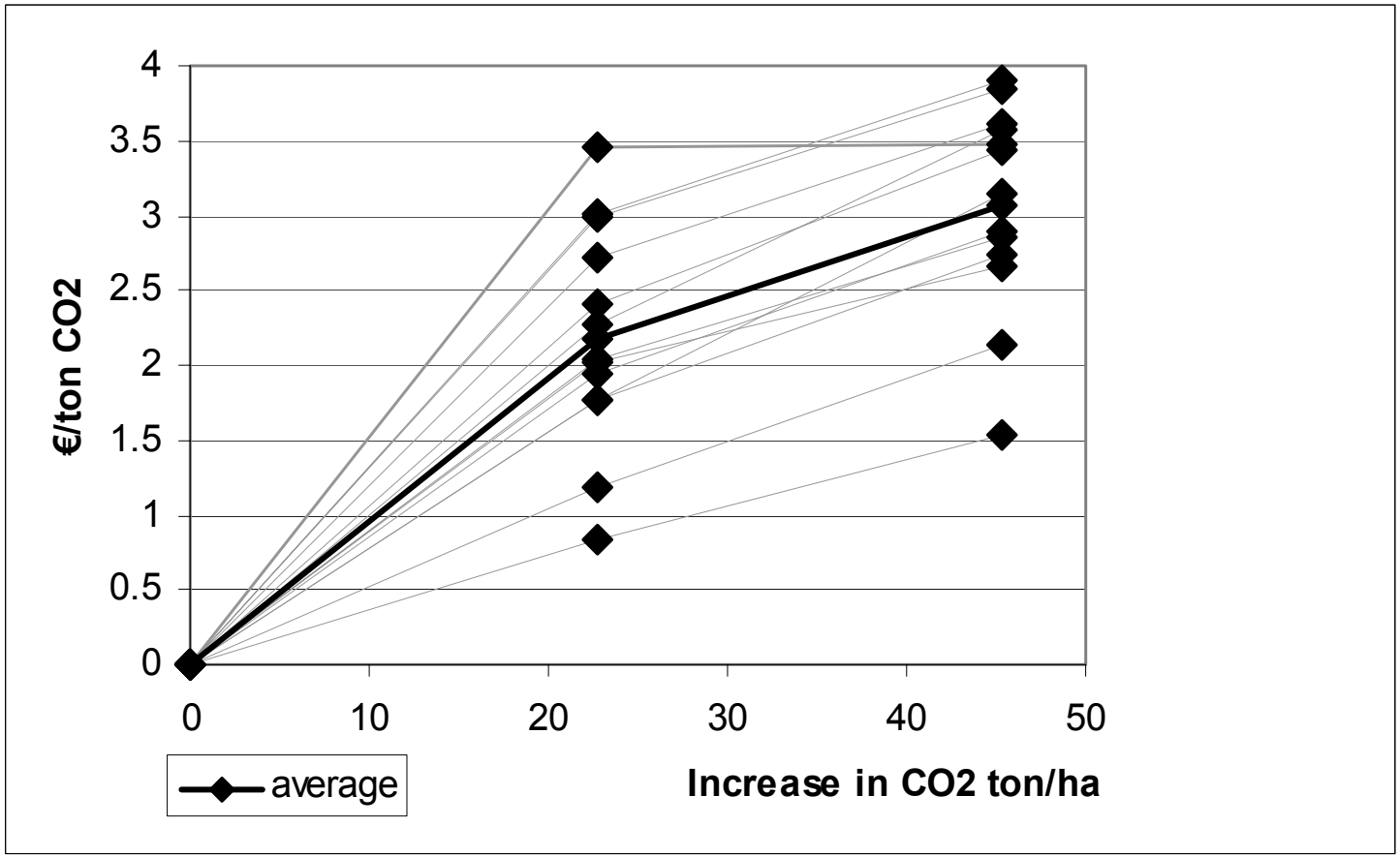
Esim. koeala 4
Keskikuutiomäärän korotuksesta (40 m3**) 2/3 toteutetaan harvennuksia muuttamalla (lähinnä viivästäminen**

- **Harvennuksia voidaan käyttää vain tiettyyn rajaan, mitä enemmän hiiltä sidotaan sitä suurempi merkitys kiertoajan pidentämisellä**

Impacts on rotation age (plot 34)

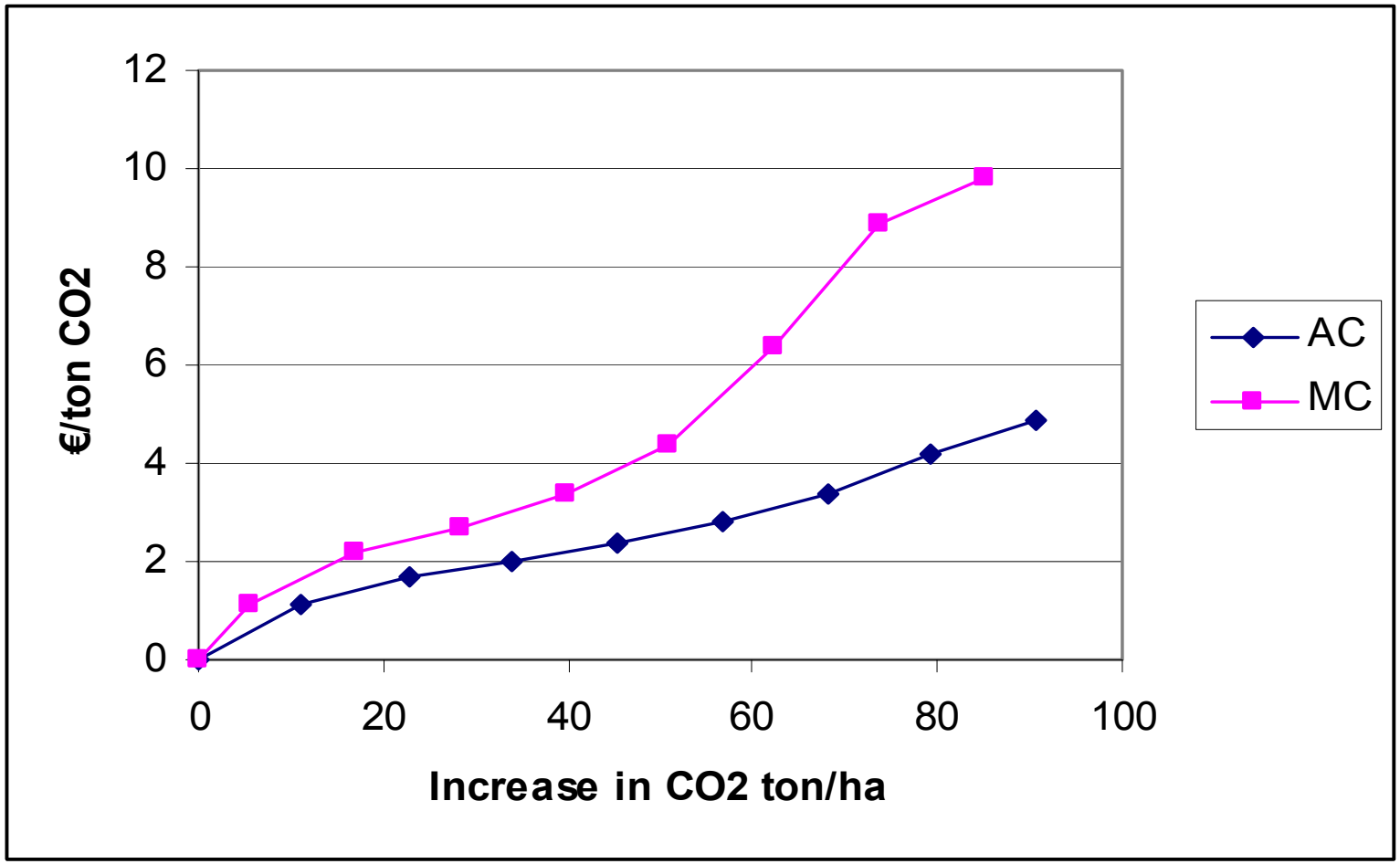


Marginal costs (present value), €/t CO_2



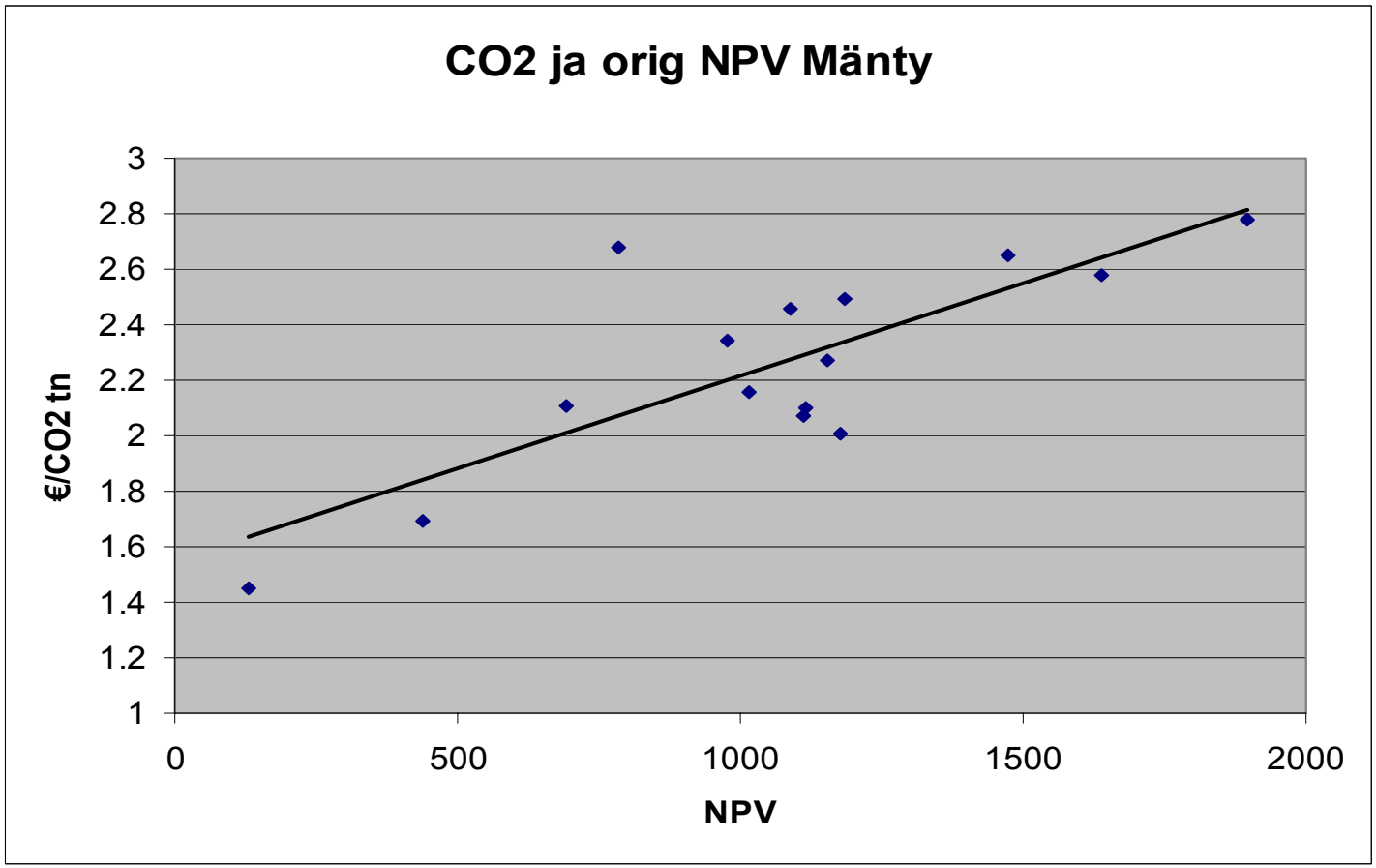
Increase in average volume (m^3/ha)

Marginal and average cost of C seq (plot 34)

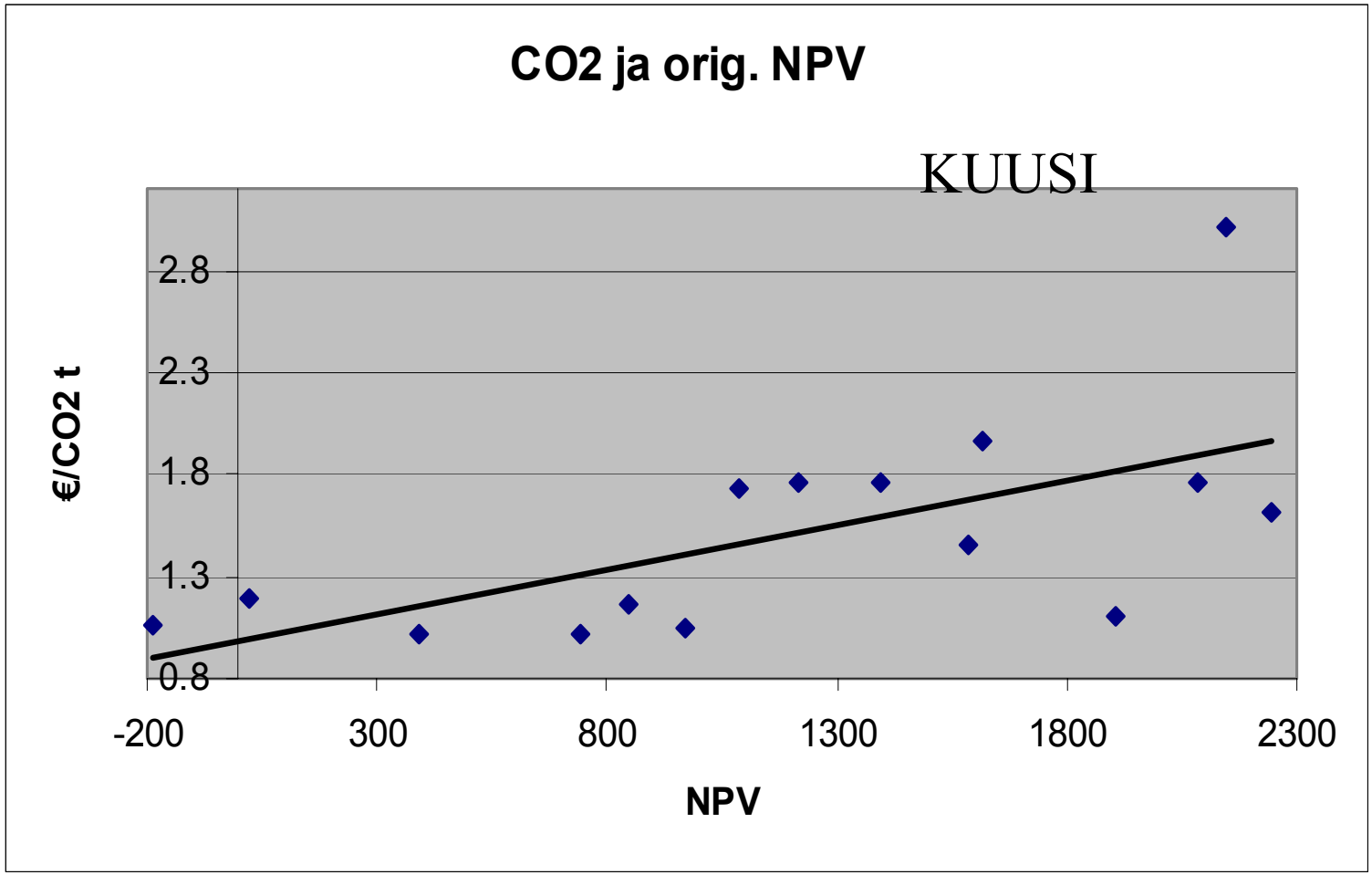


Hiilidioksiditonnin sitominen on sitä kalliimpaa mitä enemmän hiilensidontaa on jo lisätty.

Kustannukset: puulaji ja alkuperäinen tuotto



Kustannukset: puulaji ja alkuperäinen tuotto

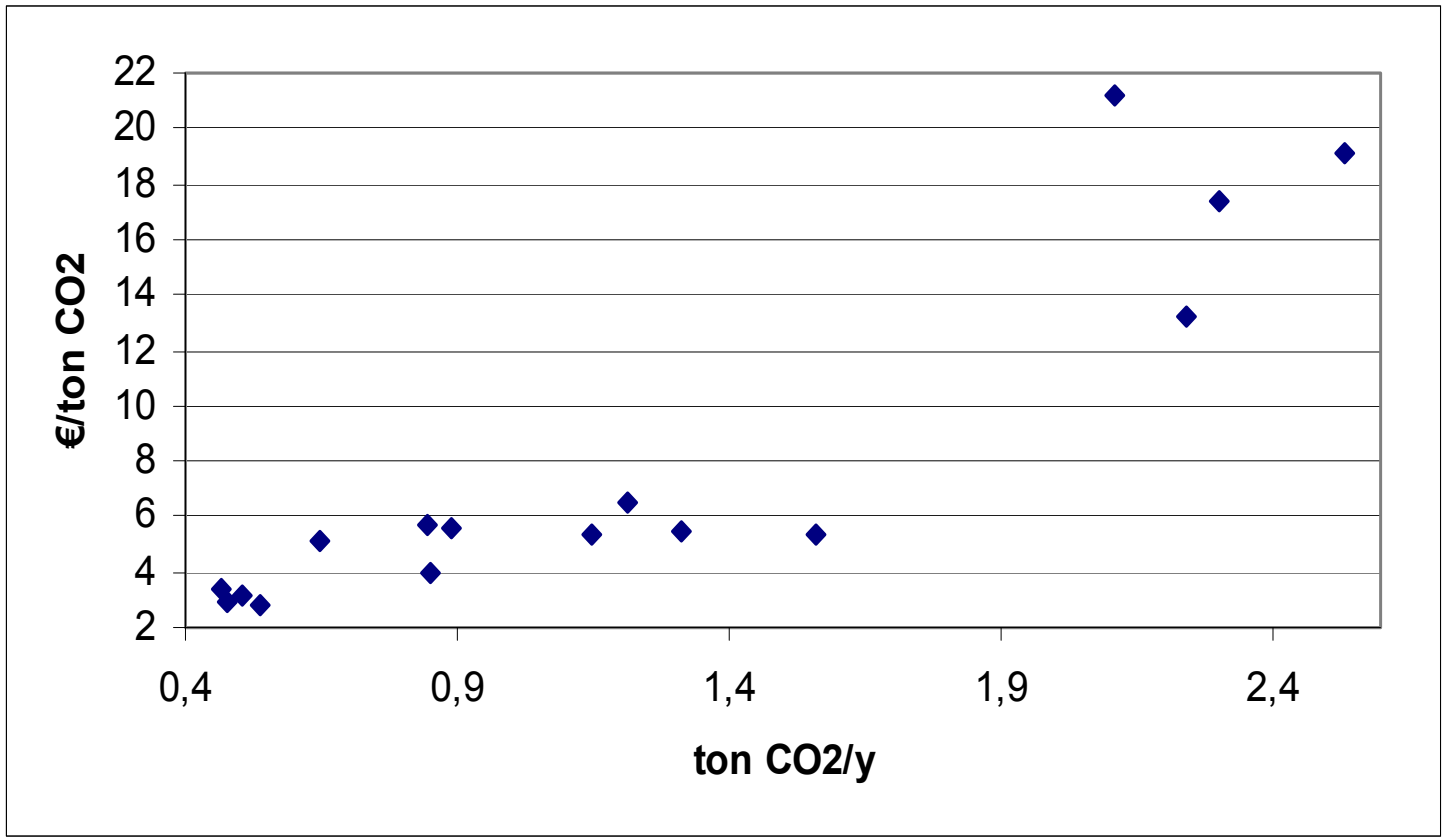


Kuusikoita näyttäisi olevan edullisempi käyttää hiilensitomiseen kuin männiköitä. Mahdollisia syitä: suurempi hiilensidontakerroin, (arvo)kasvu kärsii vähemmän volyymin nostosta, pienempi ero tukin ja kuidun hinnoissa

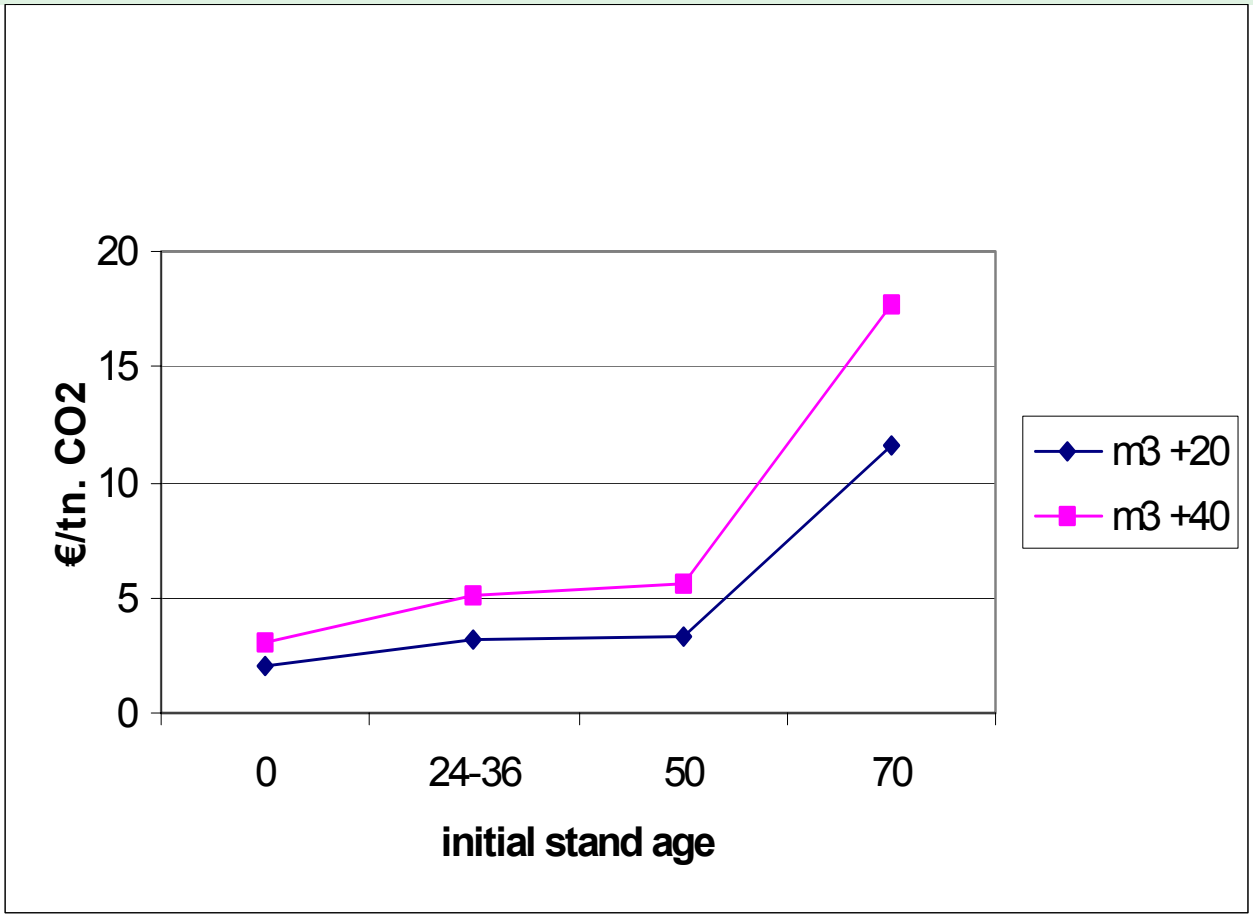
The costs and sequestration period for stands of various ages (+40 m3/ha)

Age class	Discounted cost €/ton CO_2 /ha	Sequestration period, years	Increase of CO_2, ton y^{-1} ha^{-1}	Rotation , years
Bare land	3.1	92	0.5	92
Stands of 24-36 years	5.1	57	0.8	87
Stands of 50 years	5.6	35	1.3	85
Mature stands (70 years)	17.7	20	2.3	90

Costs of carbon sequestration in relation to sequestration per year



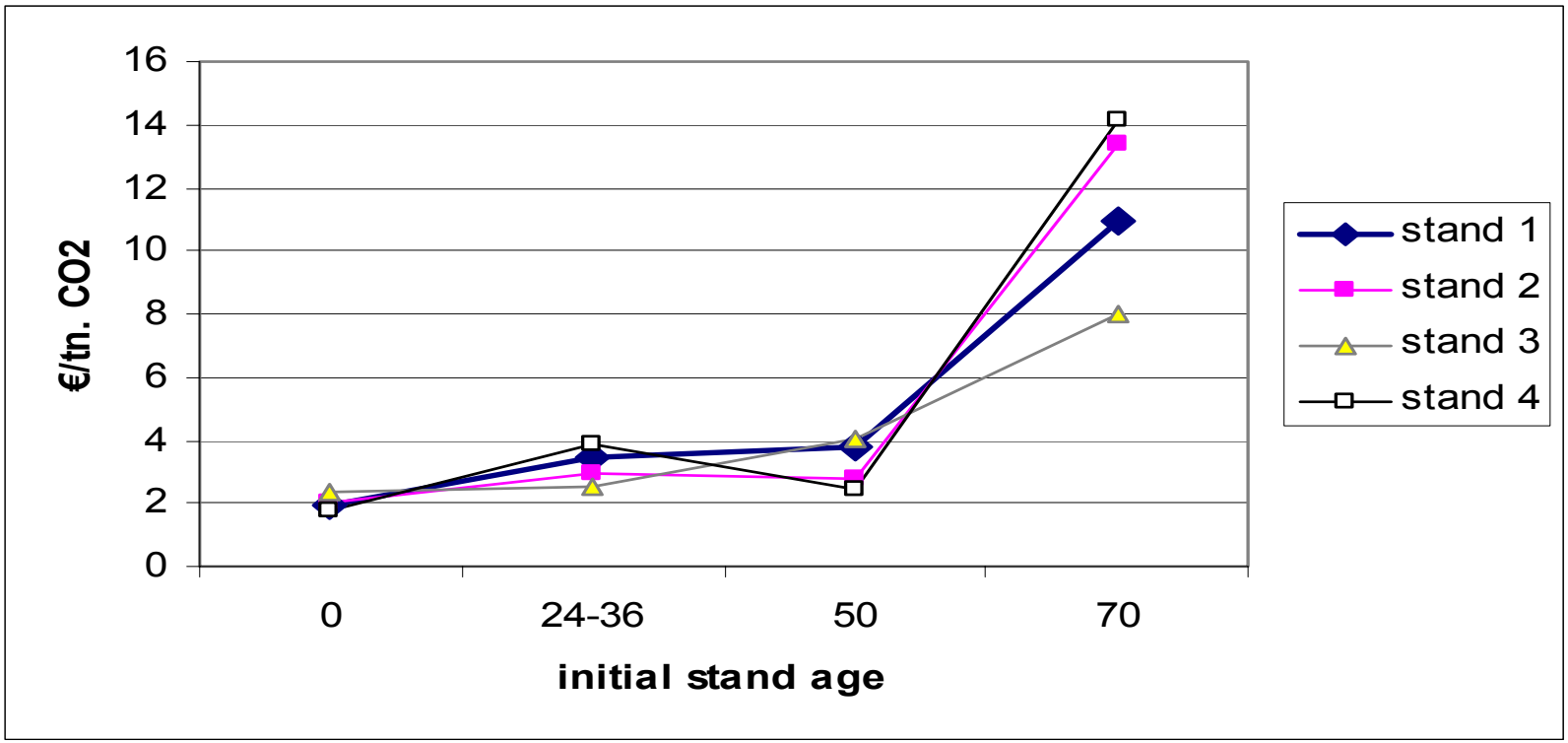
Average costs of carbon sequestration for different initial stand ages



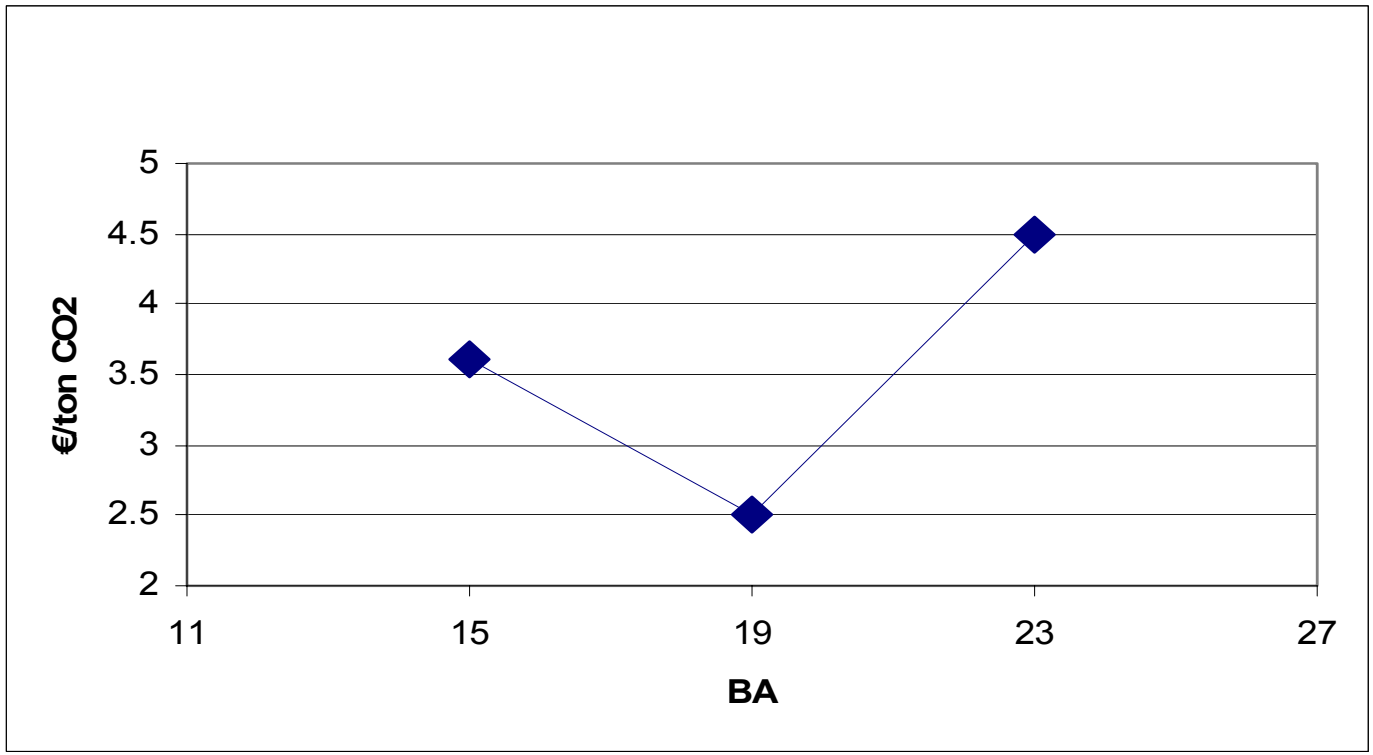
Keskitilavuutta nostettu 20/40 m3/ha kiertoajan loppuun mennessä.

70 v kustannukset selvästi kalliimmat, koska hiilen sidonnan lisäys vuotta kohti suurin. Lisäksi koko tilavuuden nosto toteutettava kiertoaikaa pidentämällä koska 70 v ei ole enää harvennettu ennen päätehakkuuta.

The variation of the costs between stands and various ages (+20 m3/ha)



Impact of initial basal area on costs of carbon sequestration



The state of the stands at later ages were obtained by simulating them according to silvicultural recommendations of Tapio. If the initial basal area differs from the one resulting from silvicultural recommendations (BA 19), higher unit costs of carbon sequestration are obtained. Higher initial basal area may diminish the biological potential and thus marginal revenue. Correspondingly, for the stands of lower basal area it may be difficult to increase the volume and thus carbon sequestration in absolute terms, due to lower growth potential of the initial stand.

Results obtained so far

- Postponing thinnings and reducing their intensity would be even more cost-effective measure to sequester carbon than increasing the rotation length.

- The more carbon is sequestered per hectare, the higher share has to be obtained by lengthening the rotation period.

- The costs of carbon sequestration is rather low with moderate amount of carbon sequestered, with a present value of 1-6 €/ton CO2

- For mature stands, the costs are considerably higher, exceeding 20 €/ton CO2, due to higher annual rate and due to the fact that only measure was the lengthening the rotation period.

How to proceed

- more plots representing different site conditions and initial states
- more simulations for Norway spruce

- thorough analysis of results
- sensitivity analysis (economic and ecological factors)

=> results for fully regulated forests
=> national level analysis

- non-optimal forest management

- take into account carbon sequestration in soils