Faustmann main contributions

- Land <u>and</u> forest expectation value
  - The forest value is the sum of expected revenues…
  - …considered in net terms (revenues minus all costs)
  - …discounted in order to be comparable.
- Link between land value and optimal rotation
  - Forest value depends on expected net revenues
  - The latter depends on forest management
  - Thus forest value depends on forest management
  - The best management maximizes the forest value

Faustmann assumptions

- An infinite series of like rotations is
  - helpful for mathematical simplification
  - useful for practical applications
  - politically interesting for the compatibility between
    - forest economics
    - sustained yield in the long term
    - and perhaps sustainable forest management
- But the theory is much more general
  - The forest value is the sum of all future net discounted revenues
  - The best management maximizes the forest value

Samuelson (1974 and 1976)

- "Economics of forestry in an evolving society"
- Samuelson agrees with Faustmann
- What about evolution?
  - Only a few words in the article
  - "life is not a steady state"
  - "incessant change is the law of life"
  - "It is no paradox that steady state analysis is useful in the understanding of realistic trend analysis"

Objectives and method

- Analysis of change through Faustmann formula
- Practical comments more than theoretical ones
- Faustmann formula

$$B = \frac{E + rD - C.(1{,}0p)^u}{(1{,}0p)^u - 1} - \frac{A}{0{,}0p}$$

- If A is neglected or considered within rD
- the formula can be written in a different way

$$B = -C + \left[E + rD + B\right]/(1{,}0p)^u$$

Objectives and method

$$B = -C + \left[E + rD + B\right]/(1{,}0p)^{u}$$

B: Land value (Bodenwerth)

C: Reforestation costs (Culturkosten)

E: final harvest(Ertrag)

rD: capitalized intermediate net revenues (Durchforstungserträge)

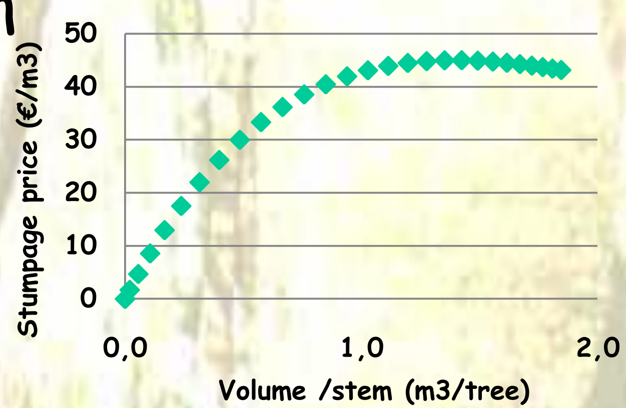
p: discount rate (Prozent)

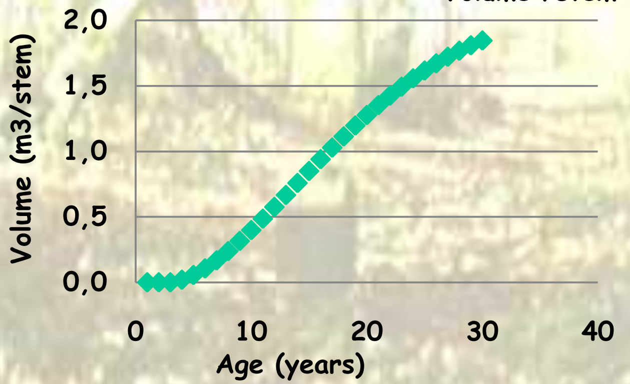
u: age at maturity (Umtriebzeit)

Case study

$$B = -C + \left[E + rD + B\right]/(1{,}0p)^u$$

- Example of a poplar plantation
- 156 stems/ha
- C= 2500 €/ha = 16 €/stem
- stumpage price➔
- volume per stem➔
- p=5%
- rotation age u = 21 yrs
- land value B = 9 €/stem





Contents: reality, expectancy and consequences of the variation of

1 2 3 4 5

$$B = -C + [E + rD + B]/(1{,}0p)^u$$

B: Land value (Bodenwerth)

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Reforestation costs

1

$$B = -C + \left[E + rD + B\right]/(1{,}0p)^u$$

- Past variation per year during 1950-2000
  - Increase of total labor costs = +3.5%
  - Increase of labor productivity= +1.7%
  - Increase of reforestation costs = +1.8%
- Future expectations
  - Increase of reforestation costs

Reforestation costs

1

$$B = -C + \left[E + rD + B\right] / (1{,}0p)^u$$

- Long-term consequences (future stands)
  - increase of rotation age
  - decrease of land value
- Short-term consequences (existing stands)
  - increase of rotation age
  - decrease of forest value

Reforestation costs

1

$$B = -C + \left[E + rD + B\right]/(1{,}0\,p)^{u}$$

- Results for C x 2 in the long-term
  - rotation age (yrs) u =21 ➔ 24
  - land value (€/stem) B = 9 ➔ -15
- Results for C x 2 in the short-term
  - rotation age (yrs) u =21 ➔ 24
  - land value (€/stem) B = 9 ➔ +1

Final harvest

2

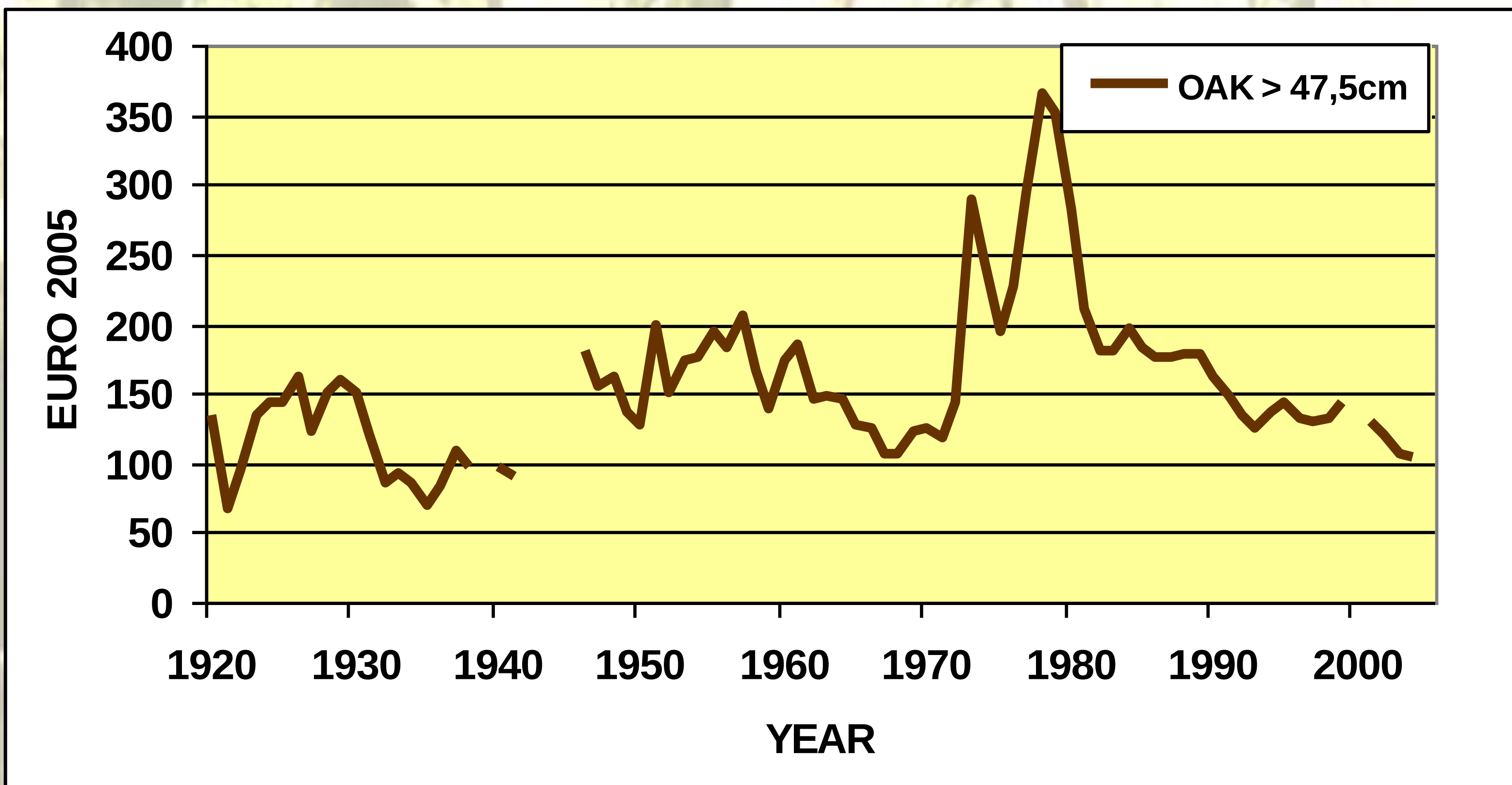
$$B = -C + \left[E + rD + B\right] / (1{,}0p)^{u}$$

- Past variations
  - prices more or less stable in the long run
  - increase of ecosystem productivity
- Future expectations
  - prices should increase with energy/carbon
  - productivity should increase and decrease
  - final revenues could increase if climate change is mitigated

Final harvest, stumpage price

2

$$B = -C + \left[E + rD + B\right] / (1{,}0p)^{u}$$



Final harvest

2

$$B = -C + \left[E + rD + B\right] / (1{,}0p)^{u}$$

- Long and short-term consequences
  - decrease of rotation age
  - increase of land value

Final harvest

$$B = -C + \left[\overset{2}{E} + rD + B\right] / (1{,}0p)^{u}$$

- Results for E x 2 in the long-term
  - rotation age (yrs) u =21 ➔ 20
  - land value (€/stem) B = 9 ➔ +44

Environmental values

3

$$B = -C + \left[E + rD + B\right] / (1{,}0p)^u$$

- Past variations
  - less and less resources per inhabitant
  - growing importance of environmental values
- Future expectations
  - growing importance

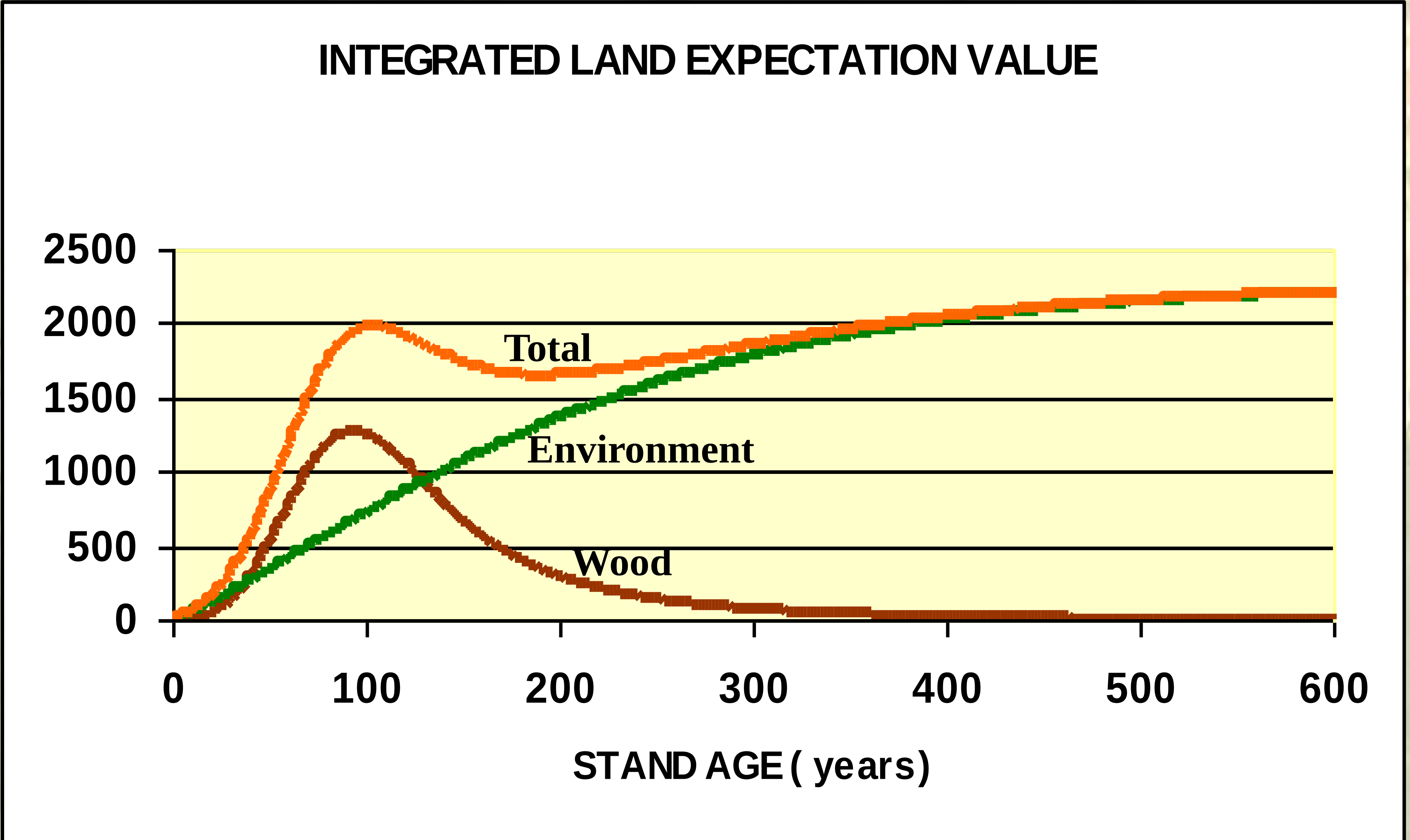
Environmental values

3

$$B = -C + \left[E + rD + B\right] / (1{,}0\,p)^{u}$$

- Long and short-term consequences
  - increase of rotation age
  - increase of land or forest value
- Special cases making the rotation tend to infinity (Strang, 1986)

Environmental values, infinite rotation age



Environmental values

3

$$B = -C + \left[E + rD + B\right]/(1{,}0p)^{u}$$

- Results for rD increasing linearly with the age (0.15 €/yr/stem)
  - rotation age (yrs) u =21 ➔ 27
  - land value (€/stem) B = 9 ➔ +39

Future land value

4

$$B = -C + \left[E + rD + B\right]/(1{,}0p)^{u}$$

- Past variations
  - changes with future expectations (see short term cases previously)
  - possible influence of the actual land market (and of population density)
- Future expectations
  - likely increase in link with previous assumptions

Future land value

4

$$B = -C + \left[E + rD + B\right] / (1{,}0p)^{u}$$

- Long-term consequences
  - diminution of the discount rate but only if it is revealed by the land market value
  - increase of rotation age
- Short-term consequences
  - decrease of rotation age
  - increase of forest value

Future land value

$$B = -C + \left[E + rD + \overset{\color{red}{4}}{B}\right] / (1{,}0p)^{u}$$

- Results when the land value doubles during the rotation
  - rotation age (yrs) u =21 ➔ 20
  - land value (€/stem) B = 9 ➔ **+12**

Discount rate

5

$$B = -C + \left[E + rD + B\right]/(1{,}0p)^{u}$$

- The choice is a problem
  - private vs social
  - even or diminishing along time
  - with or without risk
- Future expectations
  - diminishing rate along time
  - add risk to optimize the rotation age

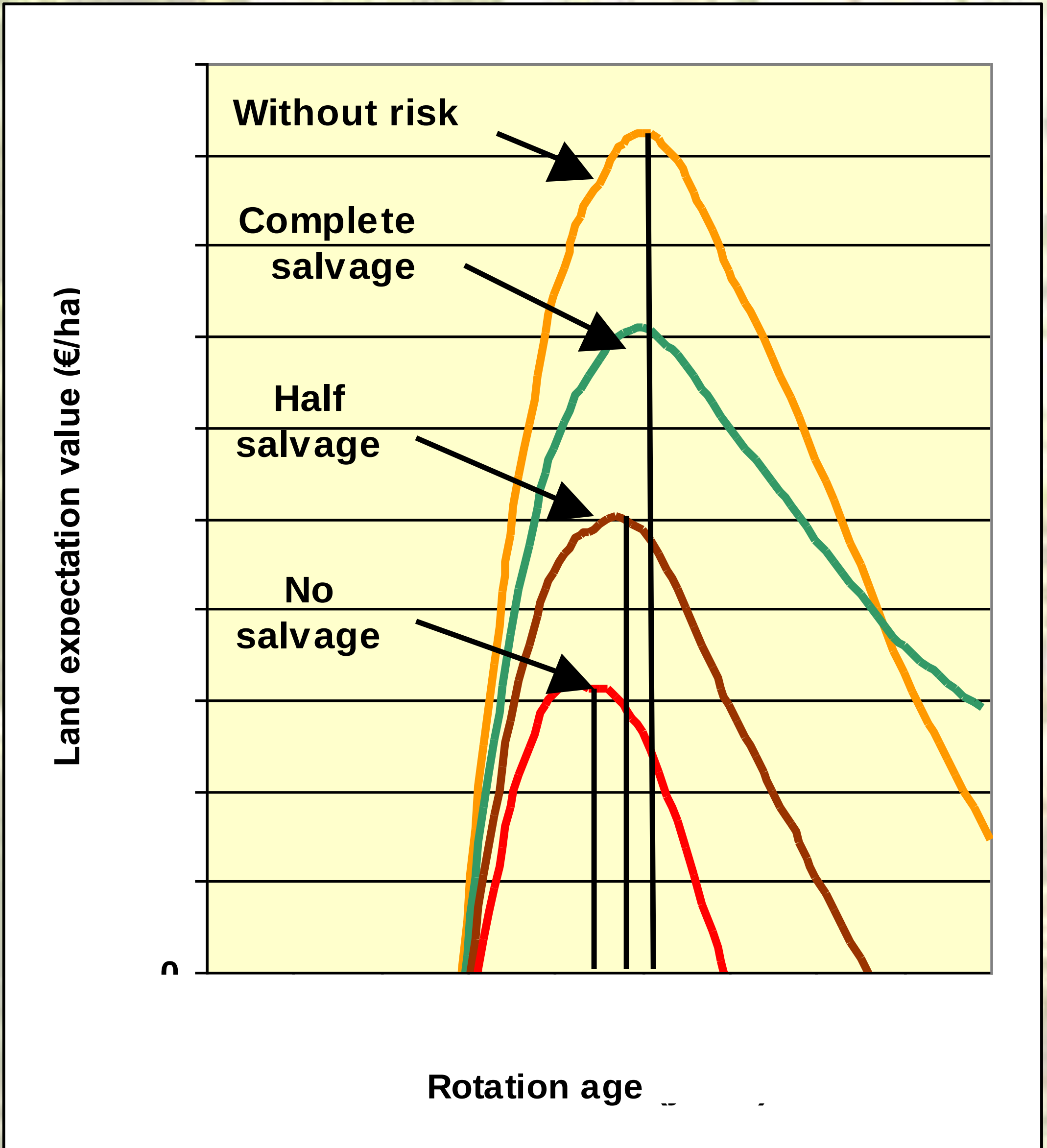
Discount rate

5

$$B = -C + \left[E + rD + B\right] / (1{,}0\,p)^{u}$$

- Long-term consequences of risk
  - decrease of rotation age when no salvage
  - But no change for a complete salvage
- Short-term consequences of a decrease
  - higher harvest value
  - higher future land value

Risk, salvage and rotation age



Discount rate

$$B = -C + \left[E + rD + B\right] / (1{,}0p)^u \quad p = 5$$

- Result for a discount rate of 4% instead of 5%
  - rotation age (yrs) u =21 ➔ 22
  - land value (€/stem) B = 9 ➔ **+19**
- Result for a discount rate of 6% instead of 5%
  - rotation age (yrs) u =21 ➔ 21
  - land value (€/stem) B = 9 ➔ **+3**

Synthesis

Scénario	Land exp. value	Rotation age
reference	9	21
C x 2	-15	24
E x 2	44	20
rD	39	27
6%	3	21
C x2 and E x 2	18	21
Previous + rD	46	23
Previous +6%	28	22

Conclusions

- Large influence of hypotheses for the future on profitability; possible negative values of forest land
- Extreme climate changes could require a fast conversion of forests to fight against dieback
- A strong interest for a local increase of environmental services (preservation areas) may require to postpone significantly the final harvest, sometimes until infinity
- In other cases, moderate effect of hypotheses on the rotation age
- **FAUSTMANN FORMULA IS USEFUL IN ORDER TO ANALYZE FUTURE CHANGES IN FORESTRY.**

Thank you for your attention!

Before Faustmann

- Optimization of the rotation period
  - e.g. Réaumur (1721) : maximum sustained yield
  - e.g. Varenne de Fenille (1791) : use of interest rate
- Calculation of the forest value
  - e.g. König (1813) : land expectation value

Questionable criticisms of the theory

- Difference between practices and theory
  - conservative practices
  - perhaps high discount rates
- Simplicity of maximum sustained yield
  - the "lowest" rate
  - towards conservative practices
- Mixing-up with internal discount rate
  - the "highest" rate
  - the shortest rotation
- Mixing-up too with the normal forest