Financial effects of silvicultural measures in pure spruce protection forests in the Bavarian Alps

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Pure spruce stands in the montane zone

Natural vegetation: Mixed mountain forests

- Picea abies: Norway spruce
- Fagus silvatica: Beech
- Abies alba: Fir
- Acer pseudoplatanus: Maple

Picture: Mosandl
Dilemma and Hypothesis

Research in spruce stands showed a dilemma:

- Stabilizing interventions have to be done early (thinning, conversion to mixed stands).
- Harvesting methods in the mountains are often expensive (cable yarding uphill or downhill) especially when interventions are done early.
- Foresters often wait with interventions until trees are big enough to earn money (but that is too late for stabilizing).
- Foresters don’t calculate with interest rates and risks.

Hypothesis for financial investigation:

- $h_0$: Silvicultural measures for stabilizing mountain forests do not create a financial benefit, even if you take in consideration interest rates and risks.
Material & Methods

- Financial comparison of two scenarios: “treated” and „untreated“ stands
- Growth series of 18 stands in the alps
- Untreated scenario: planting and (hypothetical) harvesting at age 100
- Treated scenario: plus silvicultural measures at age 40, 60 and 80
Material and Methods (continued)

- Valuation of stands using current timber prices
- Valuation of harvesting considering six different harvesting methods: (“harvester”, “combined”, “skidder”, “full-tree logging”, “cable yarding uphill” and “cable yarding downhill”)
- Calculation of contribution margins for scenario “treated” and “untreated”
- Calculation of net present values (interest rate 2%)
- Integration of risks in calculations using Monte-Carlo-Simulation:
  - Volatility of timber prices:
    Statistic of prices in 30 years
    Bavarian timber market
    (“Bayerische Staatsforstverwaltung”) (BEINHOFER 2007)
  - Calamities (snow, storm, insects):
    Survival probabilities
    (moderate and higher risk)

![Graph showing survival probability over age](image)
Methods to consider risk

- **Monte-Carlo-Simulation (5000 times)**
  Risks: Volatility of timber prices and hazards (snow, storm, insects)
  In case of hazard: reduction of timber price by 50%
  Result: Frequency distributions, mean values, variance

- **Mean-variance-approach:**
  Certainty equivalent = Mean – reduction for risk

\[
CE(Z) = M(Z) - \alpha \cdot \frac{\sigma_z^2}{2}
\]

- $CE(Z)$ = Certainty equivalent
- $M(Z)$ = Mean
- $\sigma_z^2$ = Variance
- $\alpha$ = Factor of risk aversion
  - $a/\text{investment}$ (SPREMANN 1996)
- $a$ = personal factor of risk aversion
  - 1 = normal, 2 = high risk aversion
Methods to consider risk

- **Stochastic Dominance**
  (1. Order, FSD)

  Option „treated“ (T) dominates Option „untreated“ (U), if:

  \[ T(y) \leq U(y) \text{ for all } y \]
  \[ T(y) < U(y) \text{ for some } y \]

- **Stochastic Dominance**
  (2. Order, SSD)

  Option „treated“ (T) dominates Option „untreated“ (U), if:

  \[ \int_{-\infty}^{x} U(t) - \int_{-\infty}^{x} T(t) \geq 0 \text{ for all } y \]
  \[ \int_{-\infty}^{x} U(t) - \int_{-\infty}^{x} T(t) > 0 \text{ for at least one } y \]
Which effects do we expect from interventions?

- Stabilizing effect (not calculated)
- Early revenues/expenses in treated stands
- Reduced variance of net present values in treated stands
- Natural regeneration in treated stands
- Also expenses in „untreated“ stands after hazards
Results
Results

- Differences of contribution margins: treated-untreated
  - Example Harvester:
    - treated: CM = 46 048 €
    - untreated: CM = 40 207 €
    - Difference: = 5 841 €

  Difference above zero: treatment is profitable.

- Consideration of natural regeneration:
  - Differences of net present values: treated-untreated
    - In treated scenario mixed natural regeneration grows. That saves money for conversion of the spruce stands into mixed stands.
    - Assumed amount of saved money:
      \[ CE(Z) = M(Z) - \alpha \cdot \frac{\sigma^2}{2} \]
      \[ 3 000 \text{,-} \, € \]
Results of stochastic dominance (SSD)
Conclusions

<table>
<thead>
<tr>
<th></th>
<th>Moderate Risk</th>
<th>High Risk</th>
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<tbody>
<tr>
<td></td>
<td>FSD</td>
<td>SSD</td>
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<tr>
<td></td>
<td>Mean variance</td>
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**Hypothesis:**

\( h_0 \): Silvicultural measures for stabilizing mountain forests do not create a financial benefit, even if you take in consideration interest rates and risks.

<table>
<thead>
<tr>
<th>Method</th>
<th>Mild Risk</th>
<th>High Risk</th>
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<tbody>
<tr>
<td>Harvester</td>
<td>T</td>
<td>X</td>
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<tr>
<td>Combined</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>Skidder</td>
<td>T</td>
<td>T</td>
</tr>
<tr>
<td>Full-tree</td>
<td>X</td>
<td>T</td>
</tr>
<tr>
<td>Cable uphill</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Cab. downhill</td>
<td>X</td>
<td>U</td>
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</table>

**Legend:**

- T = treated dominates, that means treatment is financial advantageous and \( h_0 \) is rejected,
- U = untreated dominates, X = no decision possible
Conclusions

In most situations treatment is financial advantageous because of:

- Early revenues in treated stands (compensate reduced volume at final harvest)
- Natural regeneration in treated stands
- Reduced variance of net present values in treated stands
- Also expenses in „untreated“ stands after hazards
Decision-making process based on financial aspects without considering risks can be misleading.

But taking the risks into account, often measures that are desirable from a silvicultural point of view can also be justified financially.
Validation of tending measures

- Tending measures normally result in negative contribution margins
- But when stands become more stable by tending, later less trees are affected by hazards: that can be a financial advantage
- Question: How strong must be stabilizing effects of tending measures to make these measures profitable?
Validation of tending measures

- Approach: change of survival probabilities
  - Step-by-step Increase of survival probabilities in Monte-Carlo-Simulation
  - Comparision of certainty equivalents in treated stands with and without tending

- At which point of increase of survival probability is the certainty equivalent with tending higher than the certainty equivalent without tending?
Result:

![Graph showing reduction of probability for hazard and difference of certainty equivalents.](image)

**Graph Description:**
- **Moderate risk**
- **Risk aversion: normal**
- Different lines represent different machine types:
  - Harvester
  - Combined
  - Full-tree
  - Skidder
  - Cable uphill
  - Cab. downhill
- Linear models for each machine type are also shown.

**Conclusion:**
- The probability of breakdown must be decreased by $\frac{1}{4} - \frac{1}{3}$.
- Then tending measures become profitable.

**New question:**
- Is that realistic?

**No proof but a hint:**
- Comparision of increased survival probability with probabilities in KNOKE and SEIFERT (2008).
## Eingangswerte: Auszahlungen

<table>
<thead>
<tr>
<th>Sortiment</th>
<th>Harvester</th>
<th>Kombiniert</th>
<th>Schlepper</th>
<th>Vollbaum</th>
<th>Seil bergauf</th>
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<table>
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<tr>
<th>Maßnahme</th>
<th>Mittelwert</th>
<th>Standardabweichung</th>
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<tbody>
<tr>
<td>Bestandesbegründung</td>
<td>2700,- €/ha</td>
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<td>Jugendpflege</td>
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<td>347,- €/ha</td>
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## Eingangswerte: Holzpreise

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<th>Sortimente</th>
<th>Erlöse ohne MwSt., Originalwerte</th>
<th>Mittlere Erlöse ohne MwSt., D-Holz-Anteil eingerechnet</th>
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<td>41 €</td>
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