# Defoliation reconsidered?

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# Talk outline

- Motivation and objectives
- Case studies examined
- Conclusions

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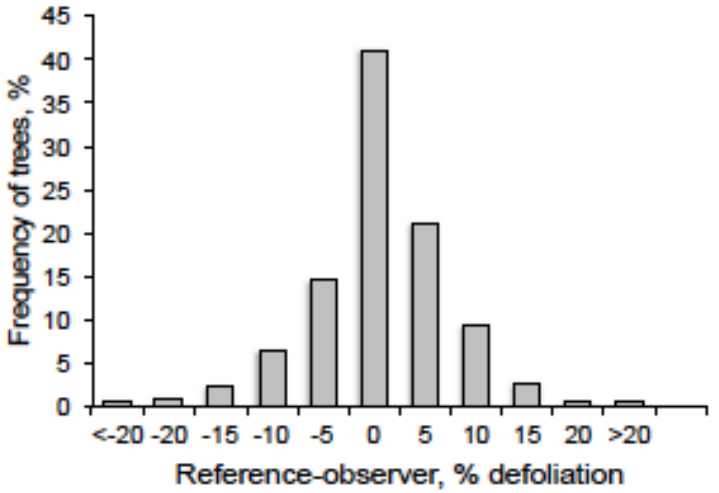
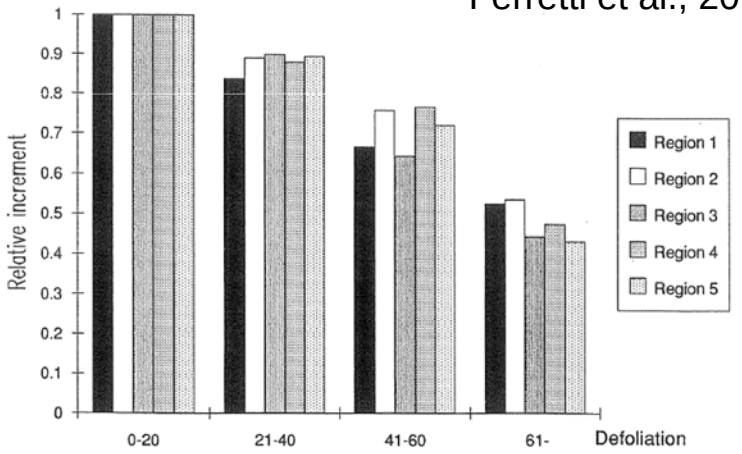
# Motivation

- Long-term (ca. 30 yrs), large-scale (Par European) data on defoliation
- Severe criticisms
  - Poor quality
  - Weak relationship with meaningful assessment endpoints
  - Not valid as SFM C2 indicator
- Contrasting evidence
  - Possibility to control data quality
  - Relationship with tree growth
- Great potential
  - If defoliation is related to quantitative indicator of tree growth and productivity > improved meaning and interpretation




Ferretti et al., 2013




Sodeberg, 1993

# Objective

- To evaluate whether a relationship exists between defoliation and objective, quantitative indicators of tree vigour, health and productivity:
  - Periodical Basal Area increment (BAI) or periodical Diameter Increment (DI)
  - Crown productivity (shoot lenght and needle biomass)
  - Leaf traits (chlorophyll fluorescence, stable carbon and oxygen isotopes)

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# Case studies

- Case study 1. Defoliation and BAI on Level II plots (several species) in France (RENECOFOR)
- Case study 2. Defoliation and DI on Norway spruce on Level I plots in Trentino, Italy
- Case study 3. Defoliation, crown productiviity and leaf traits on Norway spruce along an elevation gradient in Trentino, Italy

# Case studies - data resources

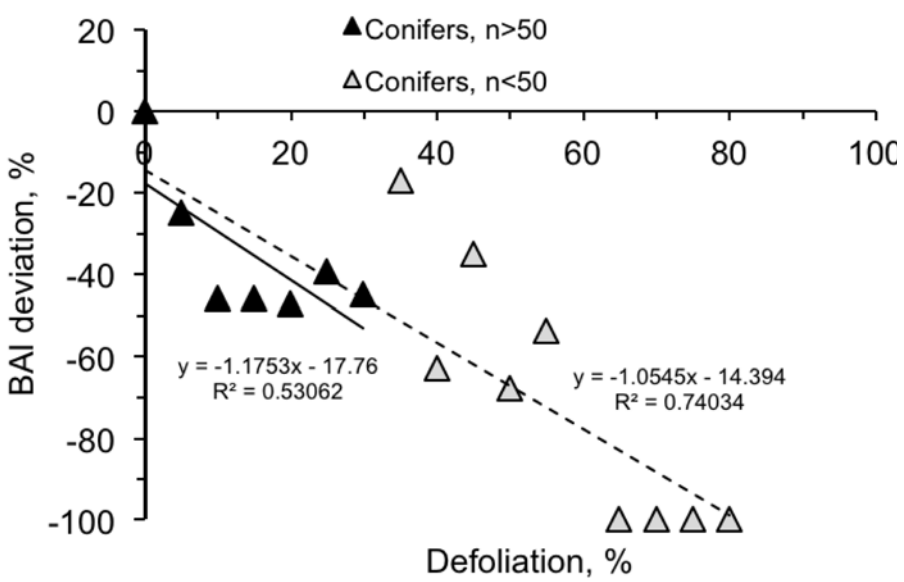
- **Case study 1. Defoliation and BAI on Level II plots (RENECOFOR) France**.
  - Two growth periods
  - 1995-2004 (47 plots, 2008 trees, conifers)
  - 2000-2009 (63 plots, 3116 trees, conifers and broadleaves)

- **Case study 2. Defoliation and DI on Level I plots in Trentino, N. Italy**.
  - Two growing periods (pooled)
  - Norway spruce
  - 2001-2005 (13 plots, 136 trees) and 2005-2009 (13, plots, 111 trees)

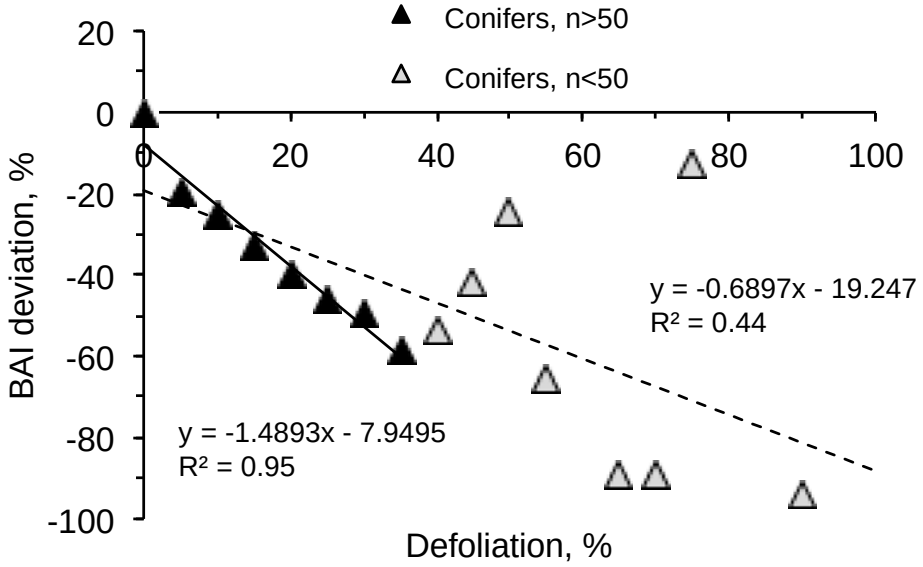
- **Case study 3. Defoliation, crown productiviity and leaf traits on an elevation gradient in Trentino, N. Italy.**
  - 9-27 Picea Norway spruce trees randomly selected along an elevation gradient (900-1500 m asl). Elevation gradient taken as a proxy gradient for several stressors (e.g. climate, ozone, radiation).

# Case study 1: France, conifers

1995-2004




2000-2009

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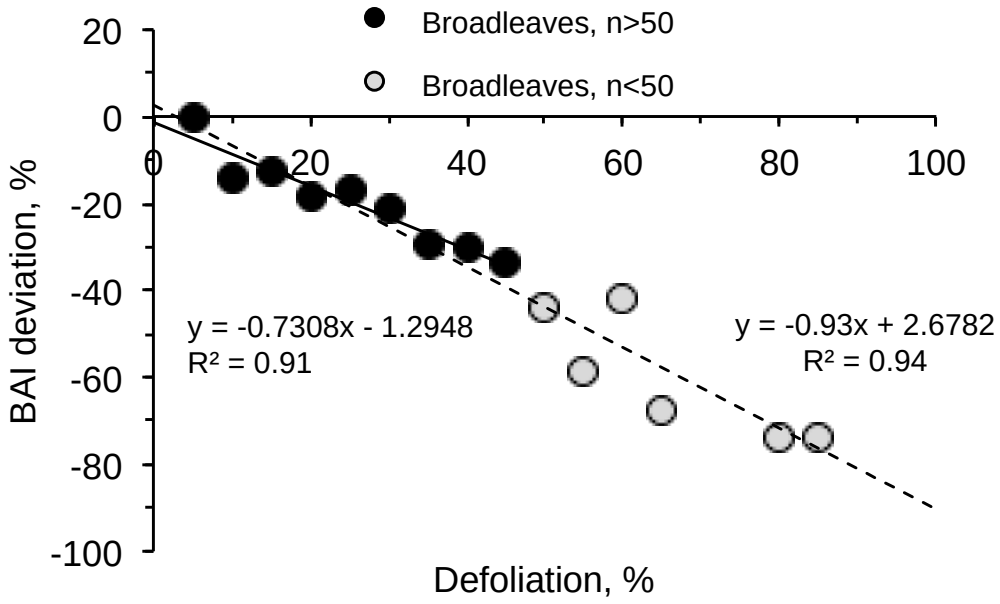
# Case study 1: France, 2000-2009, broadleaves

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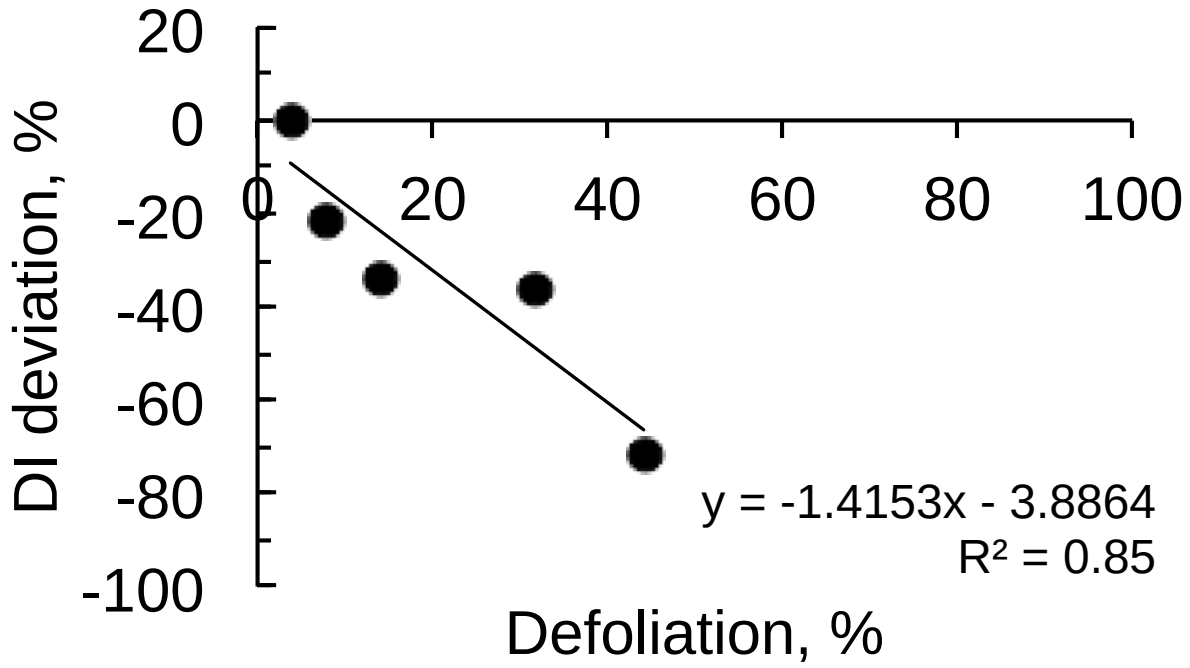
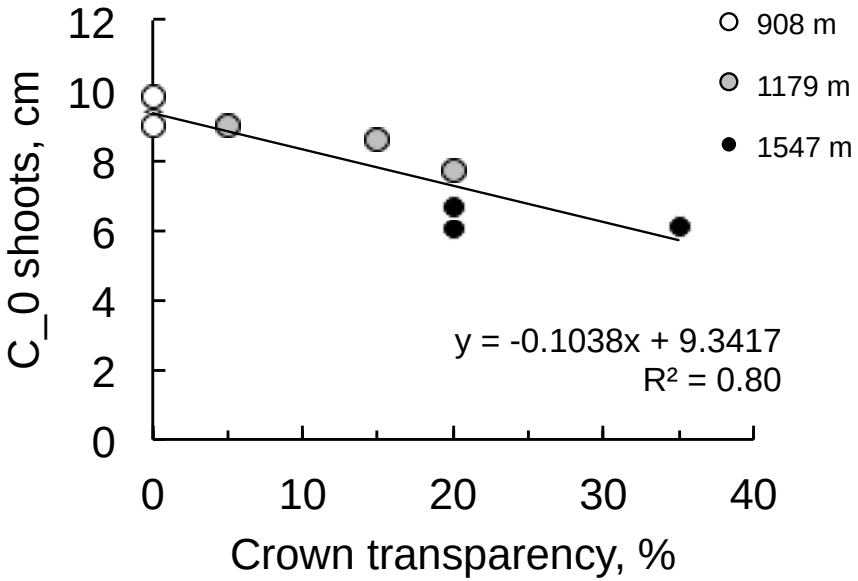
# Case study 2, Trentino, N. Italy

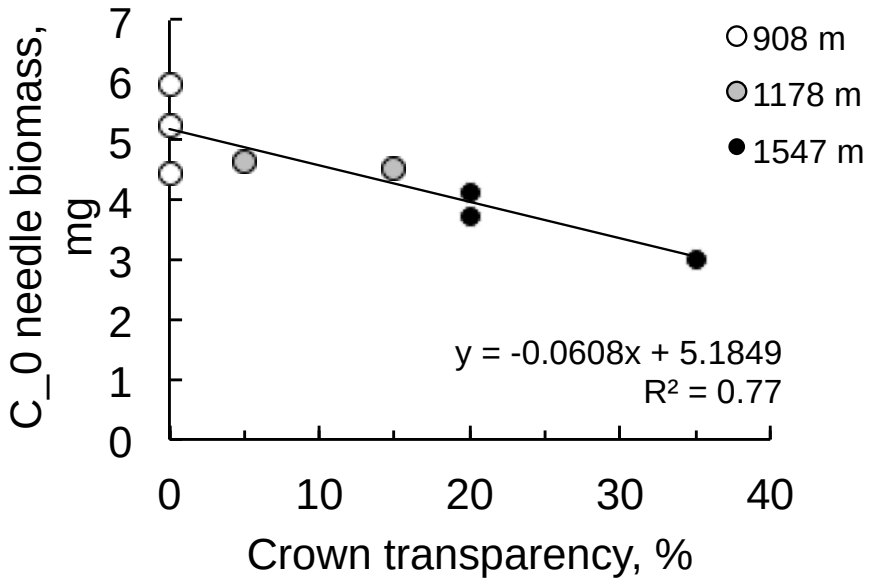
## Norway spruce 200-2005; 2005-2009



# Case study 3, Trentino, N. Italy,

## Norway spruce elevation gradient

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# Case study 3, Trentino, N. Italy,

## Norway spruce transect

### Effect of elevation

| | Anova, p-level | | Direction of change |
|---|---|---|---|
| | *n=27* | *n=9* | |
| *Variable* | | | |
| Circumference, cm | 0.134 | 0.823 | = |
| Crown transparency, % | **0.0034** | **0.011** | ↗ |
| Visible damage to crown, % | **0.0035** | **0.001** | ↗ |
| Shoot lenght, cm | - | **0.001** | ↙ |
| Needle weight, mg | - | **0.041** | ↙ |
| FV/FM | - | **0.009** | ↙ |
| $\delta^{13}C$ | - | 0.255 | = |
| $\delta^{18}O$ | - | **0.011** | ↙ |

Gottardini et al., in preparation

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Gottardini et al., in preparation

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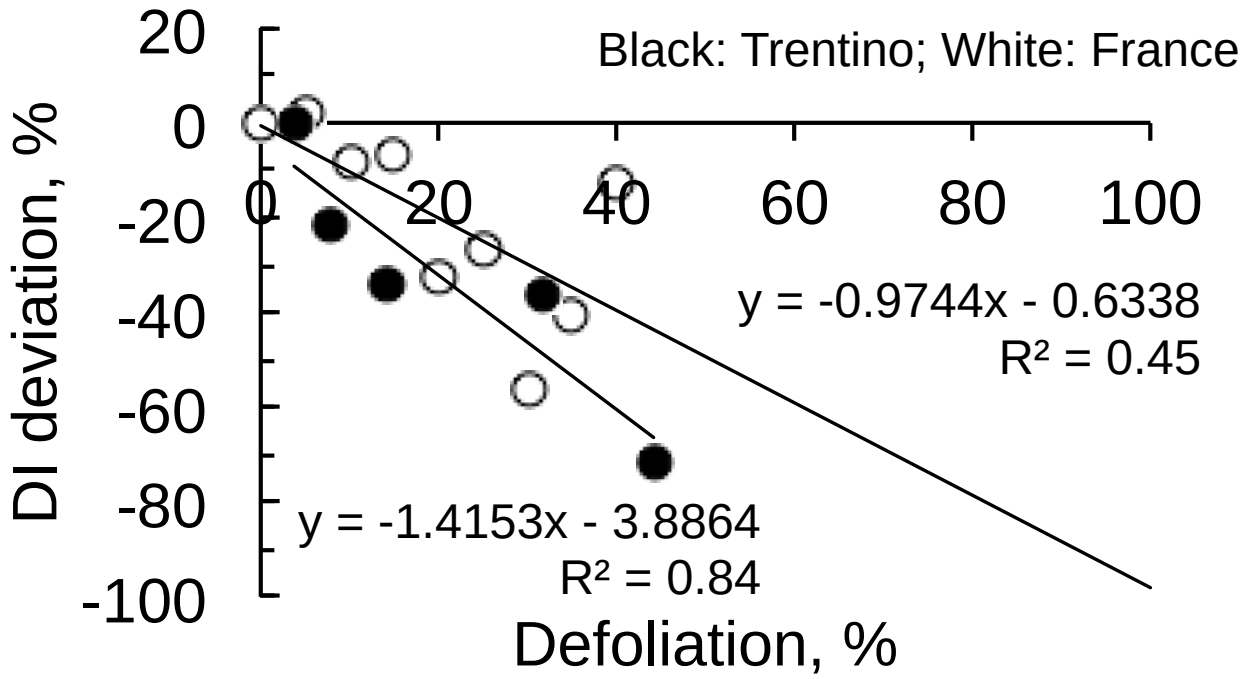
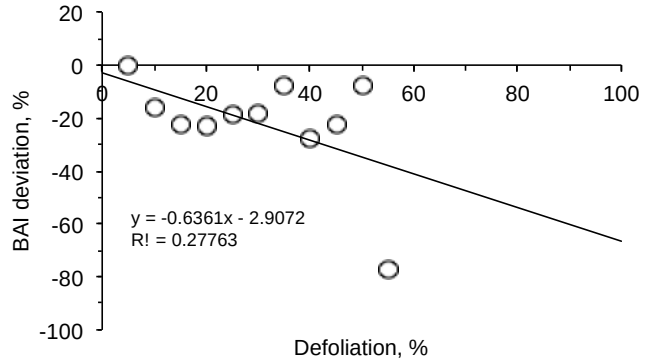
# Regularities:
# same species, different countries

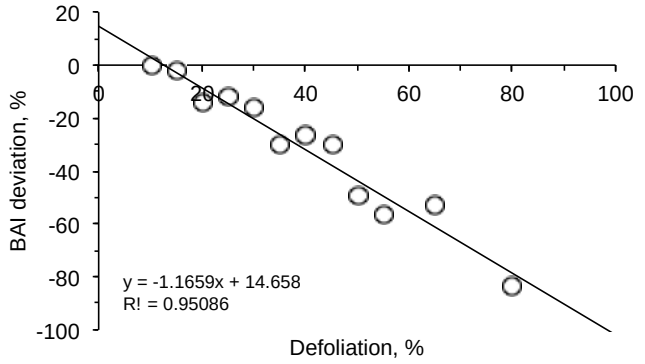
## Norway spruce, Trentino, Italy, and France



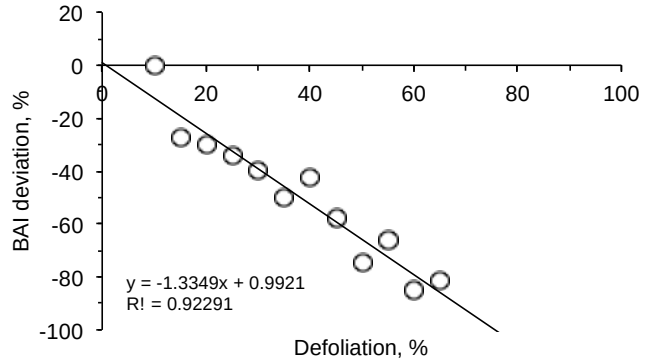
# Regularities:
# different species, same country
## France



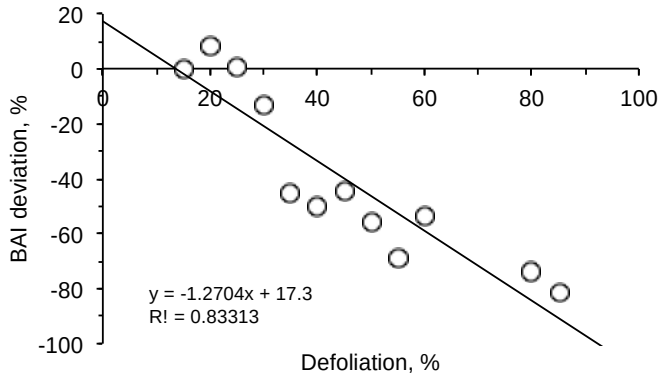

Fagus sylvatica




Quercus petraea



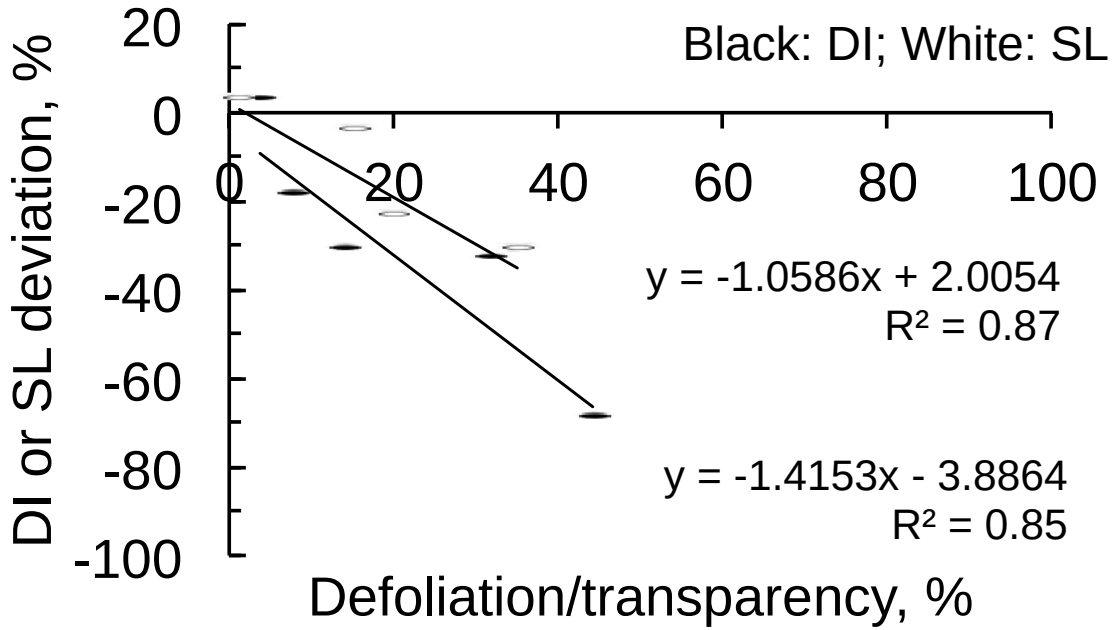

Quercus robur



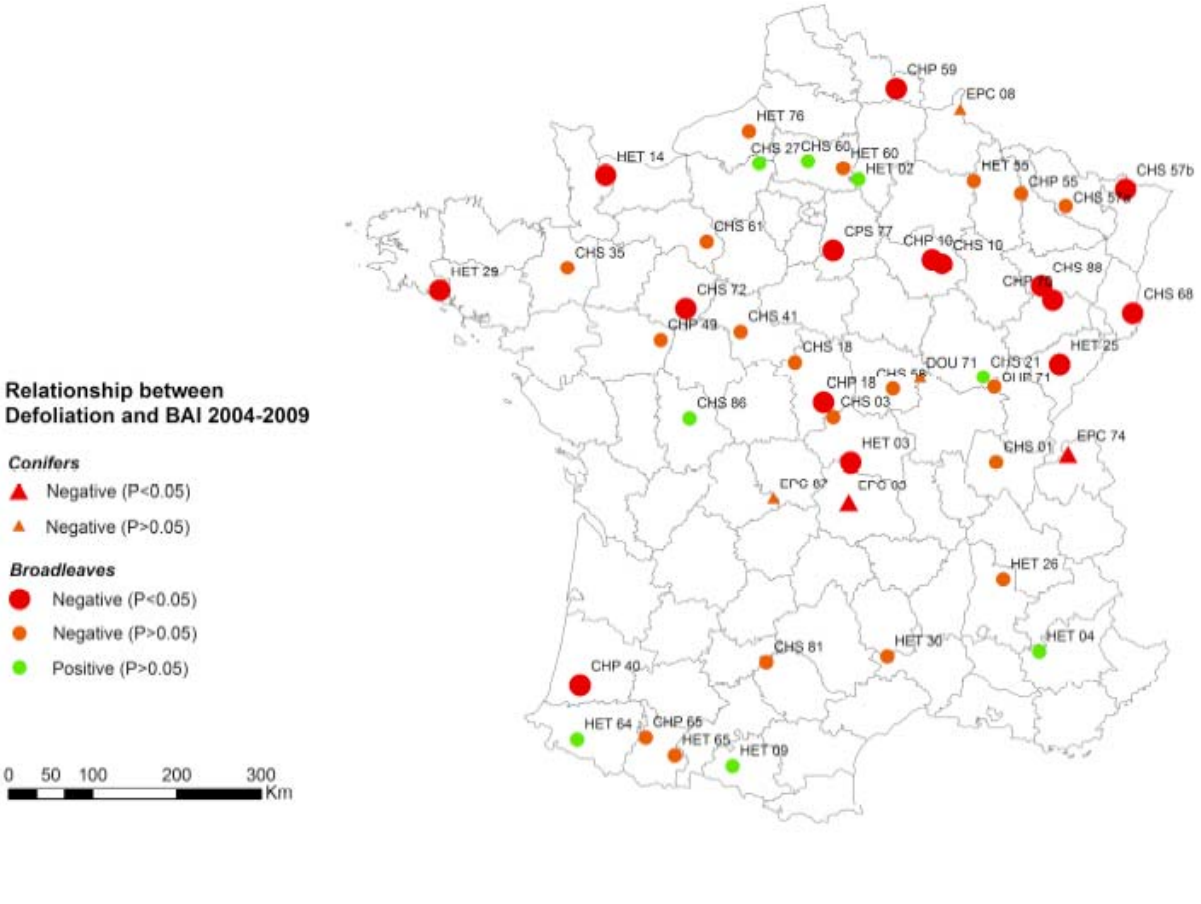

Mixed Quercus robur and Q. petraea

# Regularities:
# same species, different indicators

diameter increment (DI) and shoot lenght (SL), Trentino, Italy



# Application:
## spatial pattern of defoliation-growth relationship

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# Application: meaningful defoliation thresholds

| Species | 1995-2004 | | | | 2000-2009 | | | |
|---|---|---|---|---|---|---|---|---|
| | n | Spearman Rho | Defoliation threshold for significant reduction of BAI | Estimated % reduction of BAI per unit increase of defoliation | n | Spearman Rho | Defoliation threshold for significant reduction of BAI | Estimated % reduction of BAI per unit increase of defoliation |
| Abies alba | 520 | -0.40*** | 15 | -0.89 | 298 | -0.38*** | 15 | -0.56 |
| Picea abies | 466 | -0.11* | 25 | -1.30 | 195 | -0.17* | 20 | -0.97 |
| Pinus nigra subsp. laricio | 90 | -0.32** | none | -1.55 | 52 | -0.44** | NA | -1.47 |
| Pinus pinaster | 290 | -0.31*** | 20-30 | -1.34 | 192 | -0.52*** | 25 | -1.44 |
| Pinus sylvestris | 419 | -0.09ns | none | -1.66 | 132 | -0.40*** | 20 | -2.49 |
| Pseudotsuga menziesii | 223 | -0.33*** | 25-40 | -1.15 | 52 | -0.19ns | NA | -2.00 |
| *Conifers* | *2008* | *-0.24**** | *15* | *-1.17* | *921* | *-0.39**** | *15* | *-1.49* |
| Fagus sylvatica | 0 | - | - | - | 817 | -0.01ns | none | -0.63 |
| Quercus petraea | 0 | - | - | - | 896 | -0.23*** | 30 | -1.16 |
| Quercus robur | 0 | - | - | - | 435 | -0.27*** | unclear | -1.33 |
| Quercus robur + Q. petraea | 0 | - | - | - | 47 | -0.60*** | NA | -1.27 |
| *Broadleaves* | *0* | - | - | - | *2195* | *-0.15**** | *20* | *-0.73* |
| *Total* | *2008* | *-0.24**** | *15* | *-1.17* | *3116* | *-0.26**** | *15* | *-0.89* |

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# Conclusion

- “The various relationships consistently indicated that approximately 1% change in crown density corresponded to 1% change in growth” (Solberg and Tveite, 2000)

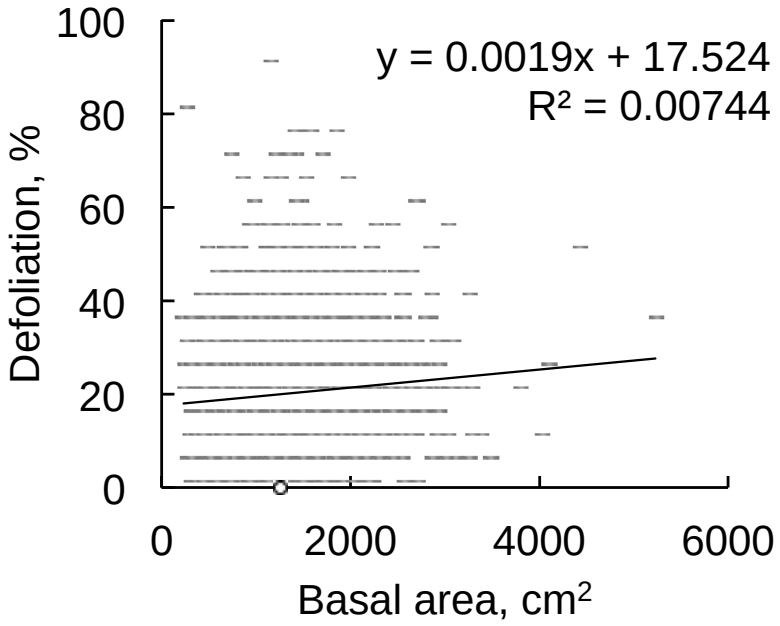
- “The correlation between crown condition and growth, although of moderate strength, did validate crown condition assessments as a meaningful, but rough measure of forest health or vigour”. (Solberg, 1999)

- Despite its “bad” reputation, defoliation can be considered as an effective indicator of forest health and vitality. Its role among the indicators of Sustainable Forest Management is justified.

- …provided adequate data quality is ensured

# Defoliation and BA, France

## Broadleaves




## Conifers