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Forest Knowledge Know-how METLA Well-being

Pine sawflies and drought – from tested hypothesis to large scale vulnerability maps

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LIFE09 ENV/FI/000571
Climate change induced drought effects on forest growth and vulnerability (Climforisk)

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Overall aims of the project

Climforisk Life+ project (2011-2014 www.metla.fi/life/climforisk)

- Estimates forest carbon balance and its scenarios over Finland (Tuomo Kalliokoski's presentation)
- Evaluates vulnerability of forests to biotic damages
- Where do we get with the methods and data that exists, and how to improve?

Pine sawfly

- Larvae eat pine needles
  - Growth losses
  - Increased mortality
  - Increased susceptibility to further damages
- European pine sawfly (*Neopridion sertificer*)
- Common pine sawfly (*Diprionidae pine*)
  - Rarer but more damaging

Fig: Ari Nikula, Metla

Pine sawfly

- Larvae eat pine needles

Drought benefits us

Winter frost below -35 C kills the eggs

(*Diprionidae pine*)
  - Rarer but more damaging

European pine sawfly larvae

Fig: Ari Nikula, Metla

This study

Can we predict vulnerability of forests to Pine sawfly outbreaks – with European level ICP I data ?

Hypothesis: outbreaks are preceded by years of low soil moisture

Motivation: successful model predictions can be incorporated to national forest planning system

Data

- ICP level I plots
  - Altogether 708 plot measured, with 15718 unique trees
  - Data measured 1985-2008
  - Main damage types identified
  - Pine sawflies (Diprionidae. i.e. D. pini, N. sertifer) are grouped

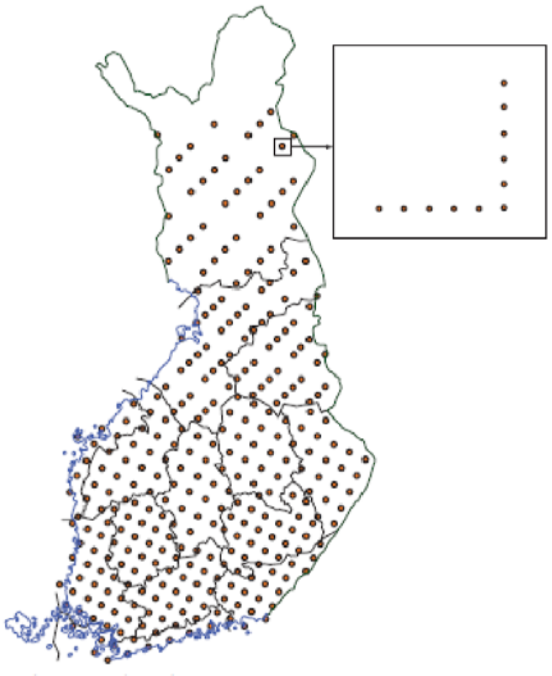


Figure 1. Locations of ICP I level forest monitoring plots.

Sawfly incidents

1995-2008 Southern Finland

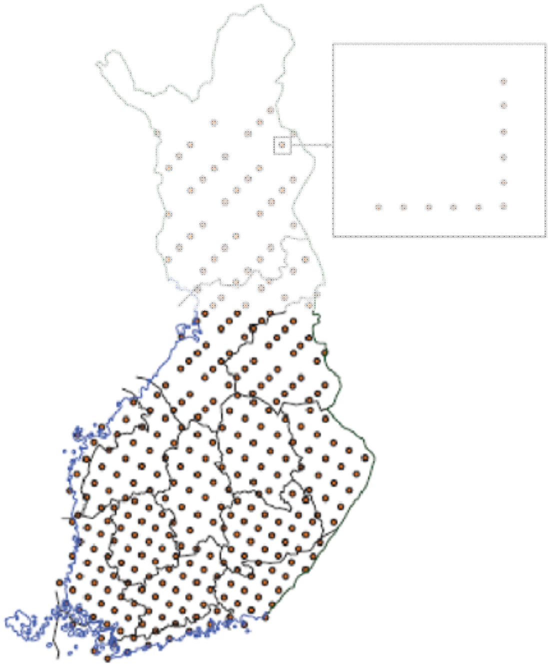
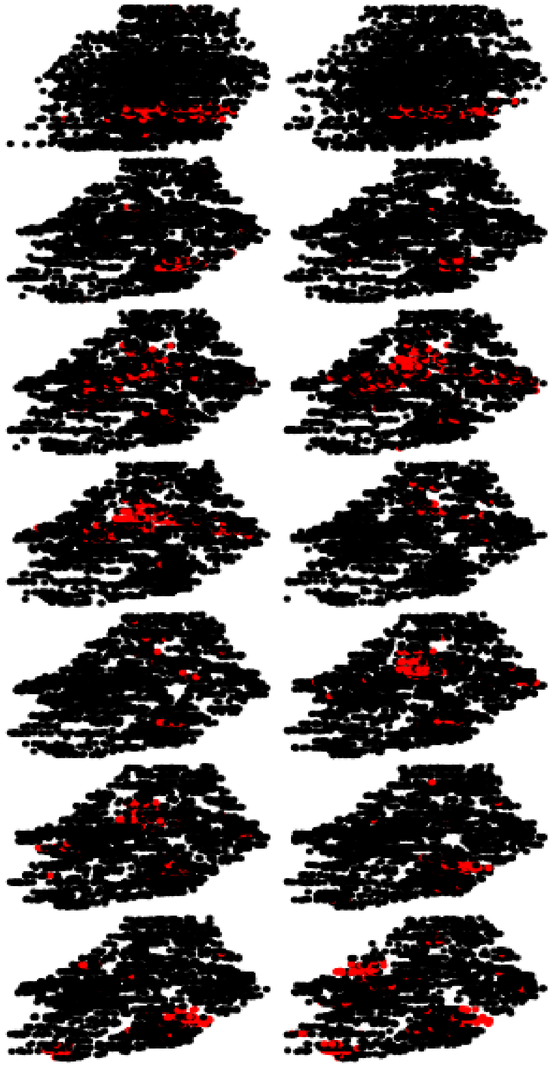
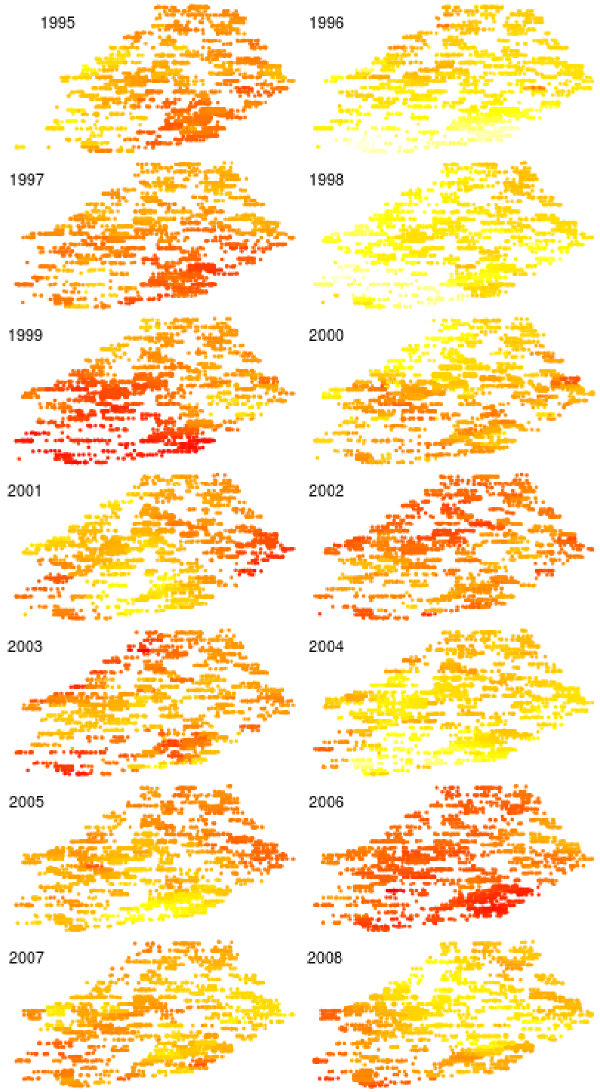


Figure 1. Locations of ICP I level forest monitoring plots.



Methods

- Modelled drought (SWI)
  - Semi-empirical GPP and water balance model PRELES
- Calibrated for Finnish conditions (Hyytiälä), and tested (Sodankylä)
  - further model calibration and testing ongoing at 8 eddy sites, good results



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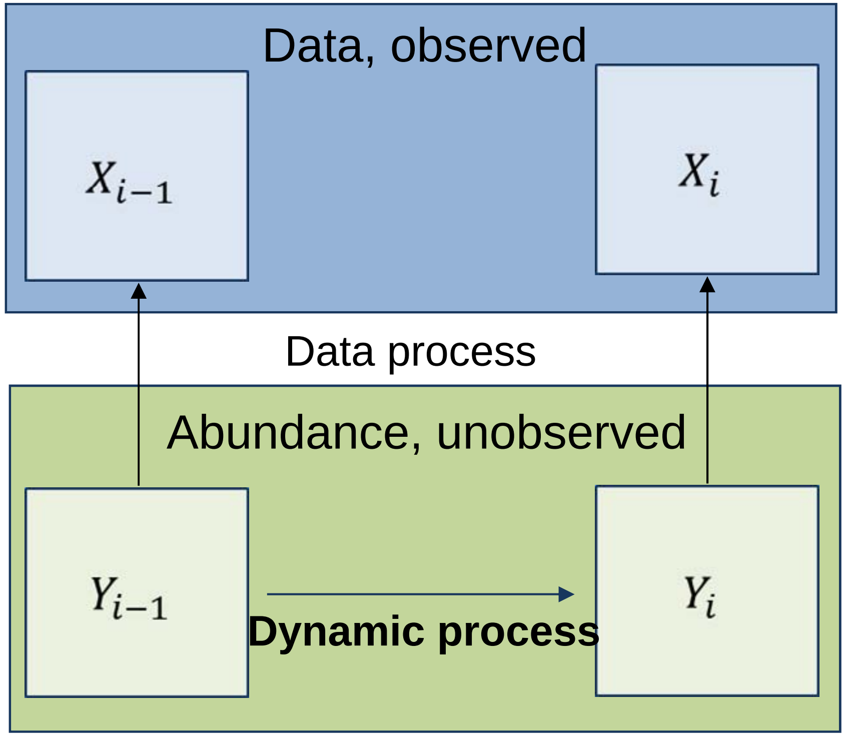
Methods – Pest dynamics model



- In a ~~perfect~~ better world, we would set up a hierarchical Bayes model as shown
- Abundance at one time point is a function of the previous value, observations are functions of the abundance
- But we do not understand the dynamic process well enough, and the data is too coarse

0 → 1

$$P(Y_i = 1|Y_{i-1})$$

1 → 1

$$P(Y_i = 1|Y_{i-1})$$

- We simplify the dynamic process in to a two-stage random walk:
  - Outbreak (1)
  - or no outbreak (0)

PROB. NEW OUTBREAK

0 → 1

$P(Y_i = 1|Y_{i-1})$

1 → 1

$P(Y_i = 1|Y_{i-1})$

PROB. OUTBREAK CONTINUES

- We simplify the dynamic process in to a two-stage random walk:
  - Outbreak (1)
  - or no outbreak (0)

RESULTS

0 → 1

$P(Y_i = 1|Y_{i-1})$

- Outbreak starts with a low probability 1.5-2.2% in a healthy forest

1 → 1

$P(Y_i = 1|Y_{i-1})$

- Outbreak continues with high probability 51-62% in sick forest

- During outbreaks, a tree is damaged with p=46-49% probability
- Outside outbreaks, p=0.5%

Damage probability increases with dryness of the site

	A	B*	C
Site type	Groves and herb-rich heath forests (78 plots)	Mesic heath forests (214)	Sub-xeric and xeric heath forests (176)
Pr. of outbreak start	**0.5%** (0.1-1.3) 0.98	**1.4%** (1.0-1.9)	**2.5%** (1.9-3.2) 1.00
Pr. of outbreak cont.	**46%** (22-72) 0.81	**59%** (47-72)	**58%** (49-67) 0.58

Drought increases the probability of outbreak continuing

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Pr. cont. DROUGHT (t-1)	**82% (57-98)** **0.98**	**73% (53-90)** **0.95**	**81% (17-100)** **0.90**

Outbreak start affected also by previous years' drought

	A	B*	C
Site type	C		ic
Pr. of outbreak start			
Pr. of outbreak cont.			
Pr. cont. DROUGHT (t-1)	82% (57-98) 0.98	73% (53-90) 0.95	81% (17-100) 0.90

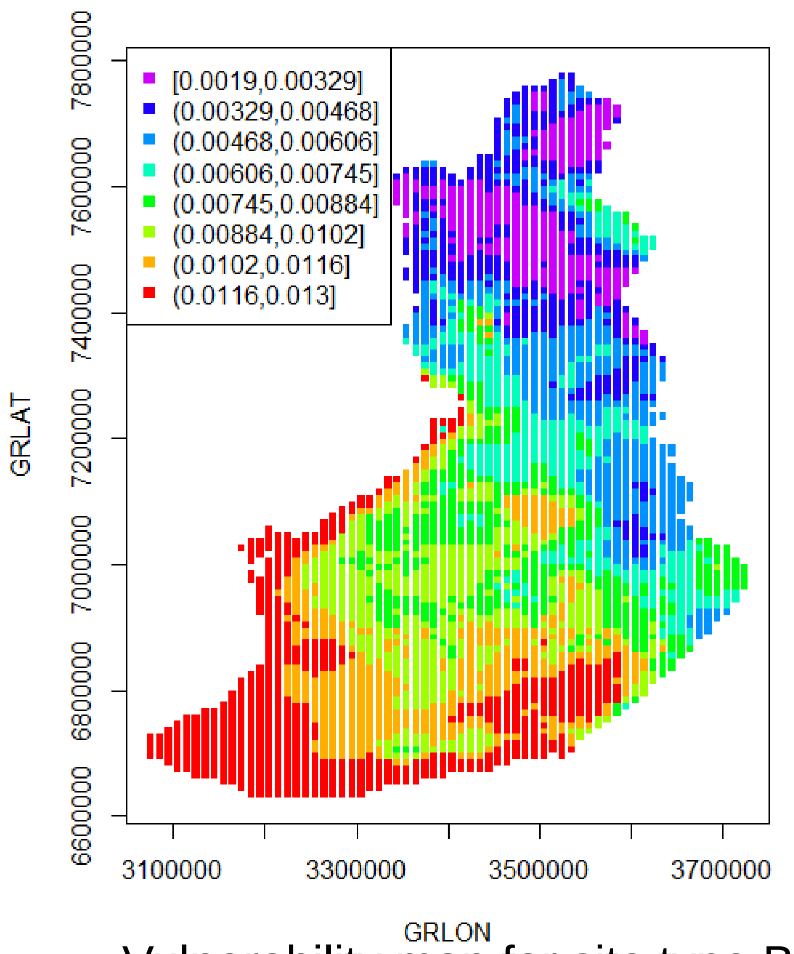
P(OUTBREAK) MUST CONSIDER DRY SUMMERS 3-5 YEARS FROM THE PAST

Vulnerability map

- Probability of winter T_{min} < -35 C explains geographical patterns

- ...combined with site type we get the map -->

Not enough data to include interannual variation of drought into the combined model



Vulnerability map for site type B

Conclusions

ICP I data supported hypotheses of climate association of Pine sawfly damages

(it is better than e.g. forest inventory data – not shown here)

The simplified Bayes-model and ICP I data provide good tools for vulnerability prediction

Our results provides basis for current day vulnerability maps of Pine sawfly, but one should be more critical when making scenario maps

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Climate change induced drought

effects on forest growth and vulnerability (Climforisk)