Effects of insect pests on CO_2 emissions from forest soils

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BACKGROUND AND AIMS

Background: Phytophagous insects have a significant effect on the C and N balance in forest ecosystems (RITCHIE *et al*. 1998, FROST & HUNTER 2007).
Input changes of litter quality and quantity can have an indirect effect on the soil organic matter decay (CHAPMAN *et al*. 2003), which results in an altered nutrient cycling (FROST & HUNTER 2004; LE MELLEC *et al.* 2009, BELOVSKY & SLADE 2000).
Aim: Apply a quantitative approach on the effects of frass litter compared to leaf litter on the soil CO_2 emissions based on field and experimental observations. Therefore, measurements of CO_2 were carried out according to the frass activity of the insects (**field study**). Additionally, a soil **microcosm experiment** was conducted to measure the soil reaction indicated by CO_2 flows under different organic matter supplies.
Hypothesis: Frass litter significantly enhances the soil CO_2 emissions compared to leaf litter.

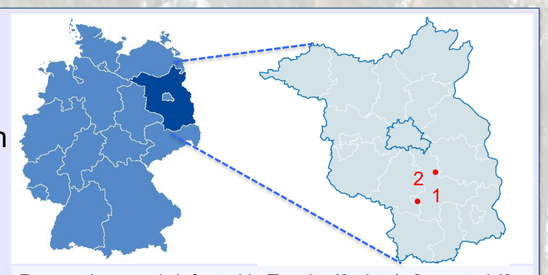
Forest ground littered with faeces from pine-tree lappet (*Dendrolimus pini* L.) (photo: M.Grüning)

MATERIAL & METHODS

Field study

Several sampling dates between 2013 and 2014 in a scots pine forest (*pinus sylvestris* L.) featuring nun moth (*Lymantria monacha* L.) infestation

Measuring chamber (n=5/plot) (photo: M. Grüning)

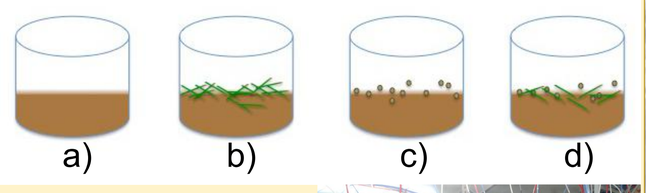


Research area: 1=infested in Teupitz (3 plots), 2=control (3 plots) in Märkisch Buchholz (Brandenburg)

Measurements of the accumulation of soil CO_2 within chambers on the Ah layer for flux calculation according to the method of JUNGKUNST *et al.* (2004a)

Microcosm experiment

Determination of the CO_2 flux of (a) pure mineral soil (Ah) compared to (b) mineral soil covered with pine needle litter, (c) frass litter of pine-tree lappet (*Dendrolimus pini* L.) on mineral soil and (d) a mixture of needle- and frass litter on mineral soil (n=5 per treatment).



- C-content of treatments b), c) and d) was equivalent
- Constant measurements during four weeks via continuous-flow-gas-chromatograph

Microcosm glasses (photo: F. Germershausen)

RESULTS

Field study

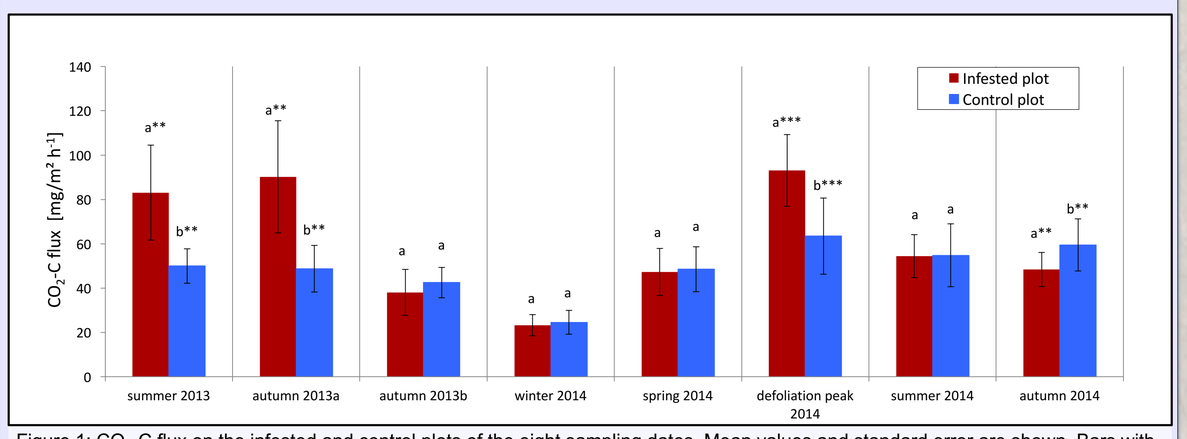


Figure 1: CO_2-C flux on the infested and control plots of the eight sampling dates. Mean values and standard error are shown. Bars with the same letter are not significantly different from each other. significance: *** p <0.001, ** p <0.01, * p <0.05.

- 2013 (population culmination) the infested plots show significantly higher CO_2 emissions (p=0.001 and p=0.003, Mann-Whitney U test)
- The following year (2014) the emissions are significantly higher (p<0.001) only during the peak defoliation period. In autumn, the CO_2 emissions show different results with higher emissions in the non-infested plots (p=0.006)

→ 32 - 46% higher soil CO_2 emissions on infested forest plots

Microcosm experiment

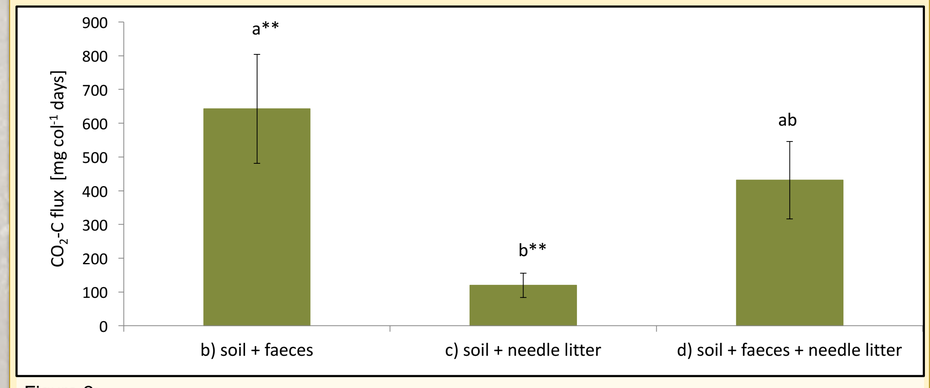


Figure 2:
Cumulative CO_2-C fluxes for 21 days of the variants b), c) and d). The basal respiration of the control a) is substracted of each variants. Bars with the same letter are not significantly different from each other. significance: *** p <0.001, ** p <0.01, * p <0.05.

- Variant c) has maximal CO_2 emissions one day after the treatment (0.69 mg C/h) whereas b) and d) show maximal emissions five days after the treatment with 9.42 mg C/h for b) and d=4.58 mg C/h for d)
- After the maximum the values decreased continuously

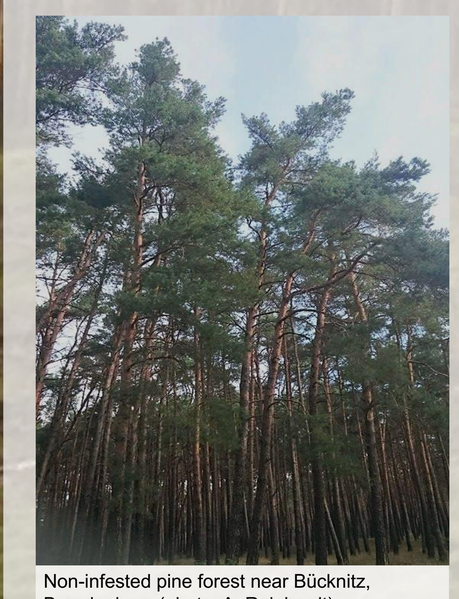
→ insect faeces causes 81% higher soil CO_2 emissions than needle litter

CONCLUSION

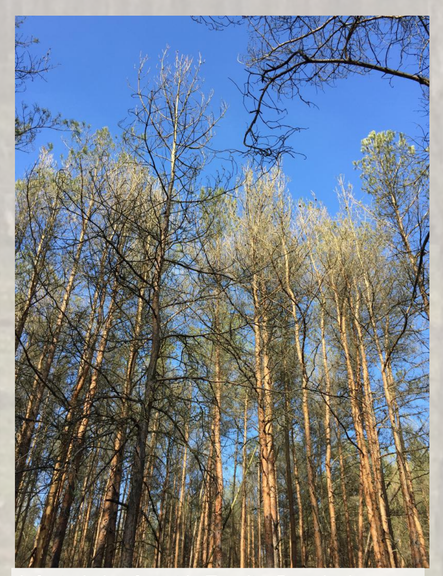
Field study

Microcosm experiment

Under both, natural and experimental conditions, insect mass outbreaks lead to a significant increase of soil CO_2 emissions.



Non-infested pine forest near Bücknitz, Brandenburg (photo: A. Reinhardt)



Infested pine forest in Teupitz, Brandenburg (photo: M.Grüning)

OUTLOOK

- Both our studies show similar results concerning the increase of CO_2 emissions. We can assume that insect pests have an overall effect on soil organic matter content both qualitatively and quantitatively. Consequently, they have a significant effect on C-mineralisation.
- It is expected that under changing climatic conditions, the magnitude, frequency, intensity and duration of insect mass outbreaks will increase (DALE *et al*. 2001).
- Since litter input is one of the largest energy and nutrient sources for decomposition processes in forests (KAGATA & OHGUSHI 2013), insect pests affect these processes significantly.
- Therefore, insect mass outbreaks should be taken into account for contributing to carbon budgeting in forest ecosystems.

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