

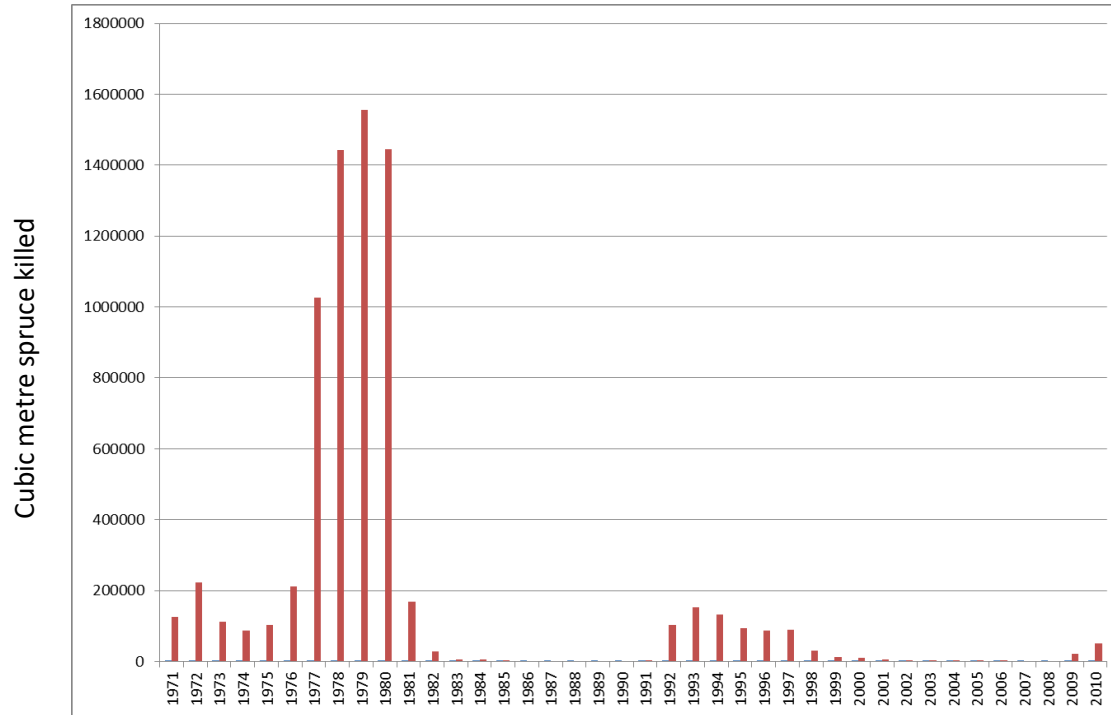
# Future transition to bark beetle outbreaks in Norway? – identifying climatic and landscape risk factors

Jostein Gohli, Paal Krokene & Bjørn Økland

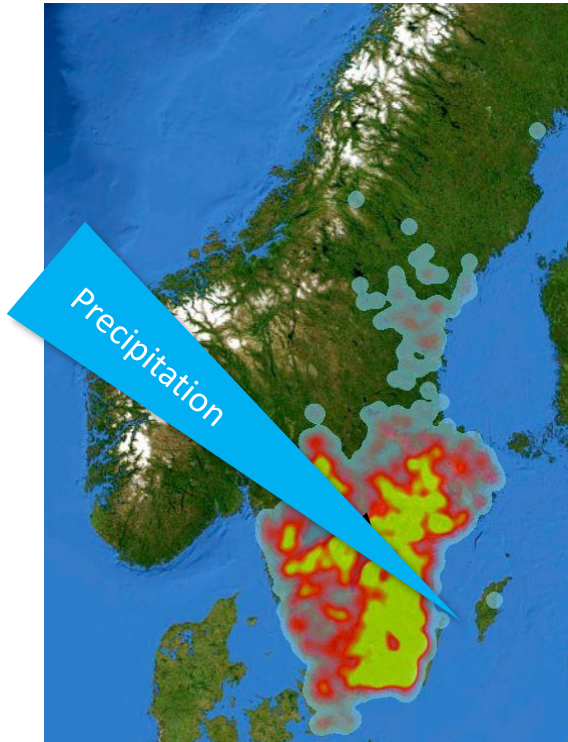


# 'The land of no bark beetle outbreaks'

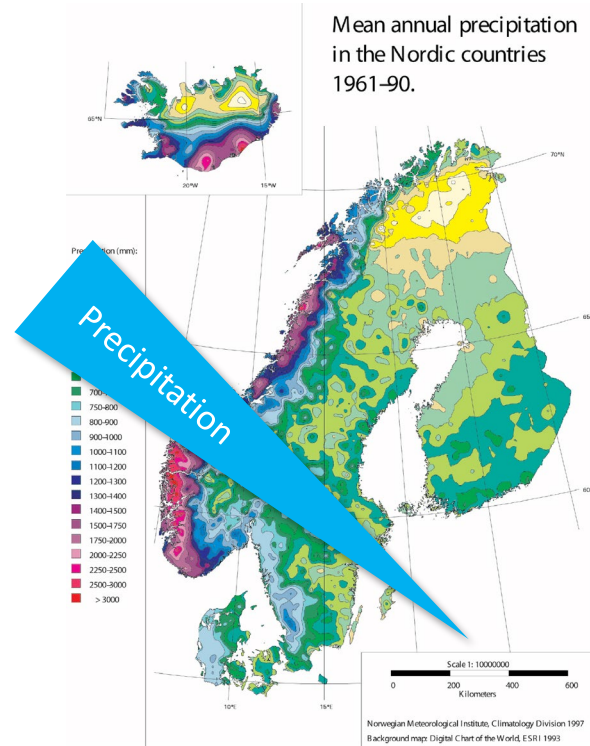
- **Outbreak in 1970s**
  - Large storm 1969. Long-lasting drought 1974-1976
  - 1971-1981: 6,5 mill. m<sup>3</sup>



# Why no bark beetle outbreaks?



Bark beetle damage 2019

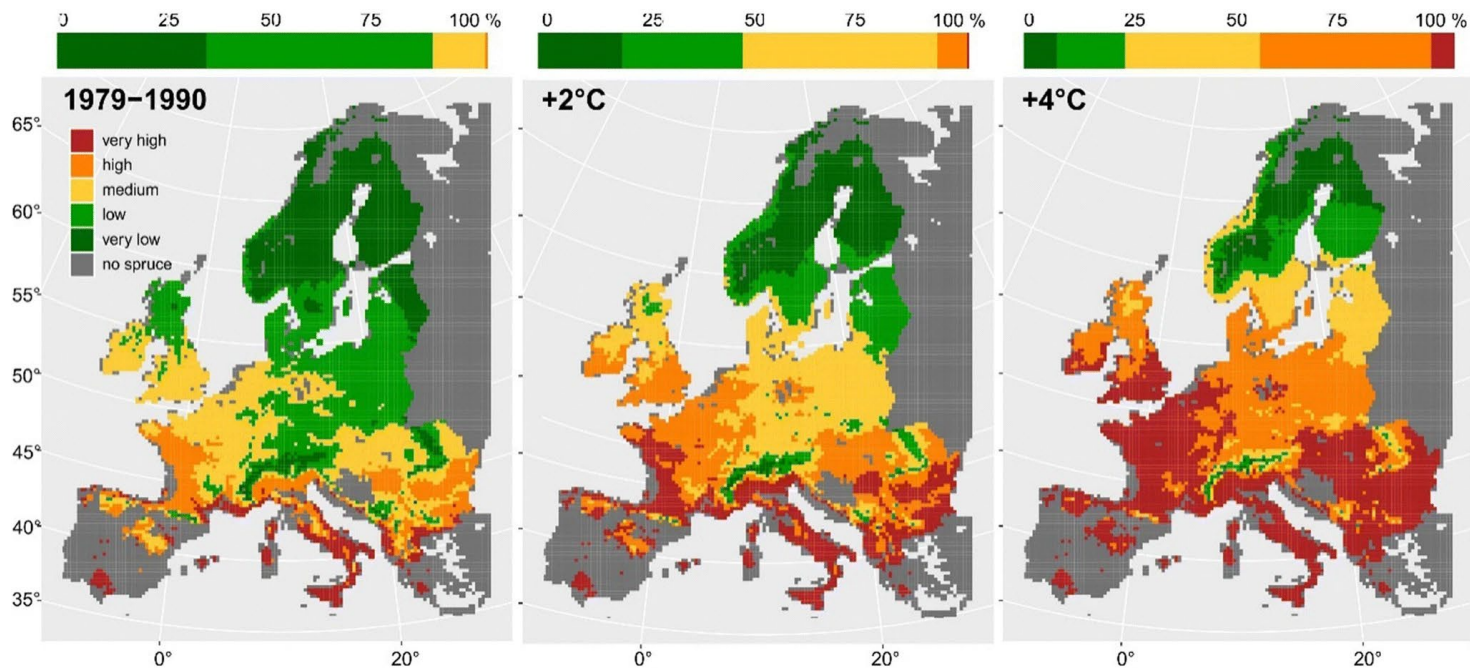


Average yearly precipitation

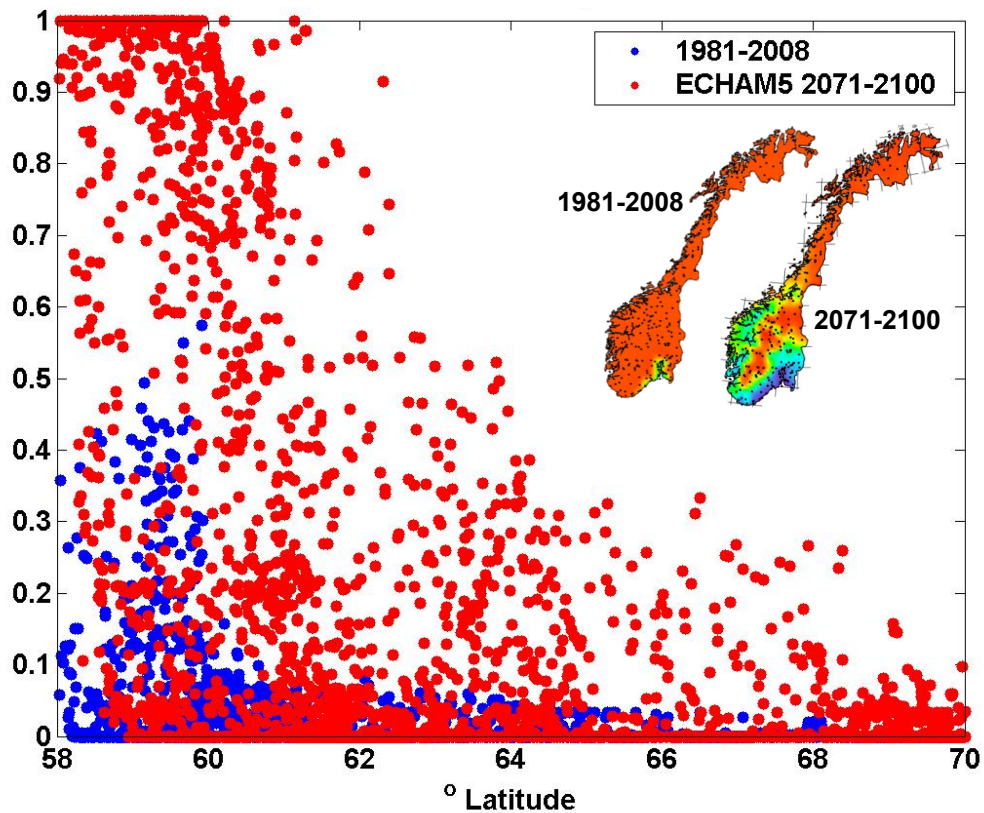
# Future climate and Ips typographus

- Warmer and wetter
- More storms, drought, and heatwaves

## Probability of a model Norway spruce stand being disturbed by bark beetles:



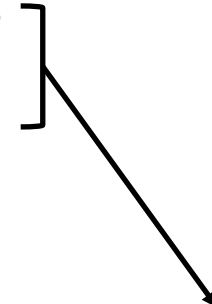
# Probability of two beetle generations per year



# Local BB populations – effects of landscape variables and climate

- What factors affect endemic BB population size?

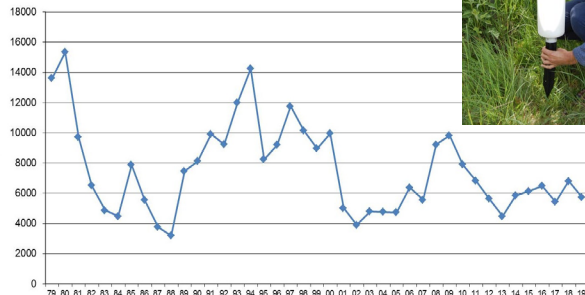
- Landscape characteristics?
- Climate?
- Regional differences?



## Ips typographus monitoring since 1979

Pheromone traps  
~100 municipalities  
~150 localities

Southern Norway



Proxy for local population size



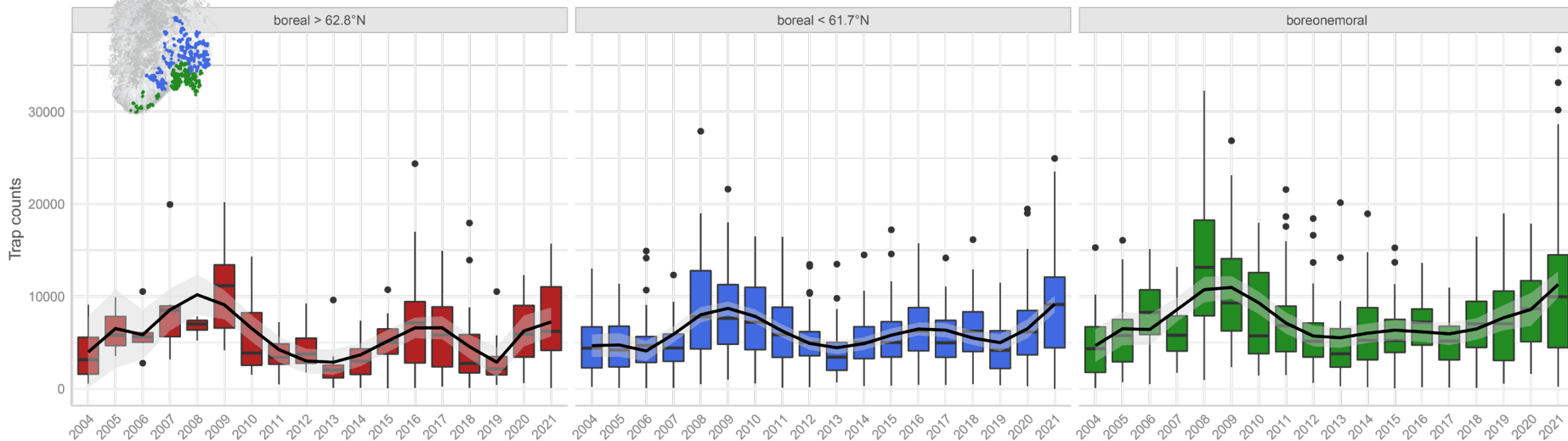
Negative binomial regression model

# Bark beetle population size



0 100 200 km

- **Bark beetle monitoring – pheromone baited traps**
  - 18 years,  $N = 1754$
- **Three vegetation/climatic zones**



**Response variable: Bark beetle trap counts** ( $N = 1754$ )

## **Landscape variables**

- Productive volume spruce
- Sum new felling site border

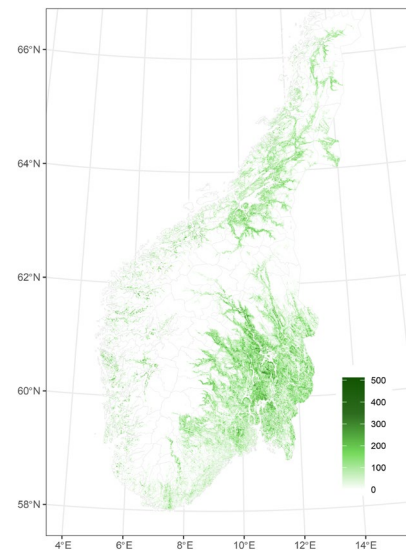
## **Climatic data** (seasonal means)

- Temperature
- Precipitation
- Soil moisture
  
- Latitude
- Longitude
- Altitude



## **Forest resource map (NIBIO):**

- LIDAR & Sentinel-2
- 16x16 meter grid
- Volume, dominant spp., age





# Predictors and data sources

**Response variable: Bark beetle trap counts (N = 1754)**

## **Landscape variables**

- Productive volume spruce
- Sum new felling site border

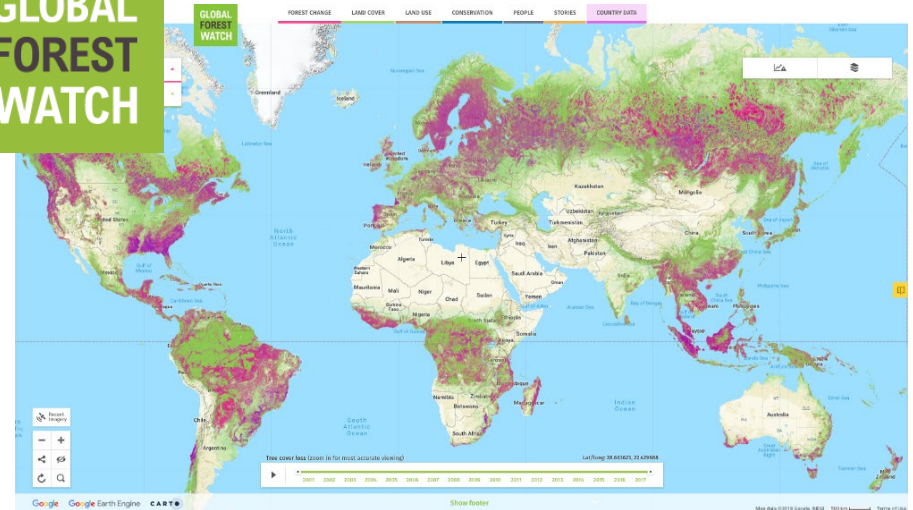


## **Climatic data (seasonal means)**

- Temperature
- Precipitation
- Soil moisture
  
- Latitude
- Longitude
- Altitude



## **Global forest watch** Tree cover loss



# Predictors and data sources

**Response variable: Bark beetle trap counts** ( $N = 1754$ )

## Landscape variables

- Productive volume spruce
- Sum new felling site border

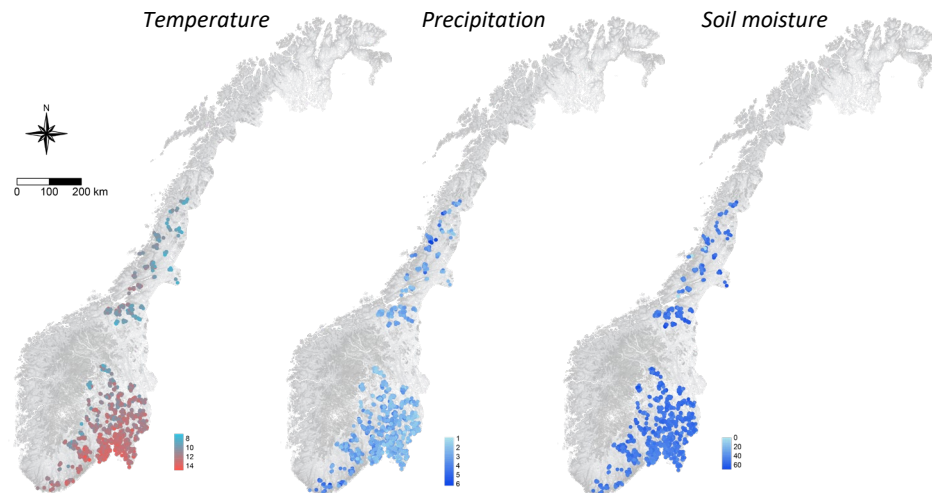


## Climatic data (seasonal means)



- Temperature
- Precipitation
- Soil moisture
  
- Latitude
- Longitude
- Altitude

**Norwegian Water Resources and Energy Directorate**  
1x1 km grid interpolated from weather station data



# Time lag on predictors

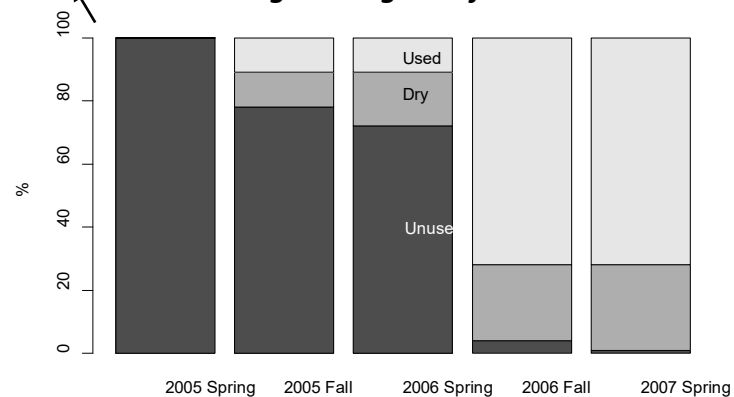
## *Lag from disturbance to increase in BB population levels*

- Clearcut borders important in cooler climates
- Weak/windfelled spruce: lag 1-5 years after logging



2004 windstorm  
in Slovakia

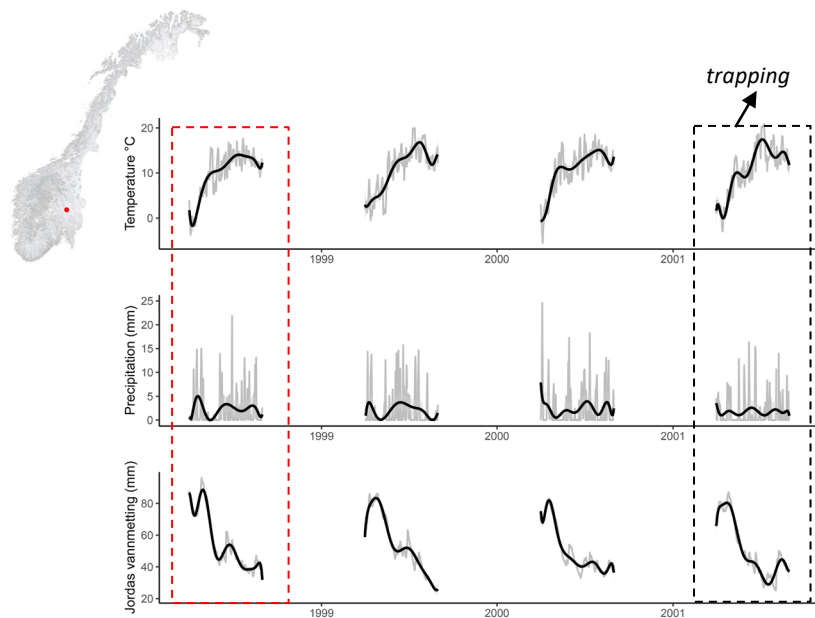
### *Time lag in using windfelled trees*



Økland, B., Nikolov, C., Krokene, P., Vakula, J. 2016. Transition from windfall- to patch-driven outbreak dynamics of the spruce bark beetle *Ips typographus*. *Forest Ecology and Management* 363: 63–73.

# Time lag on predictors

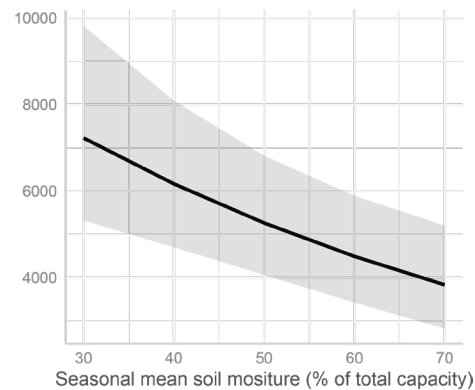
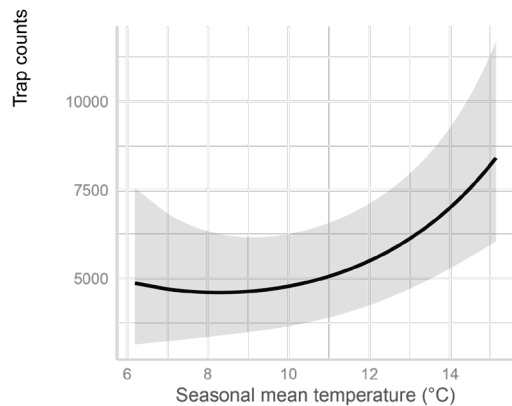
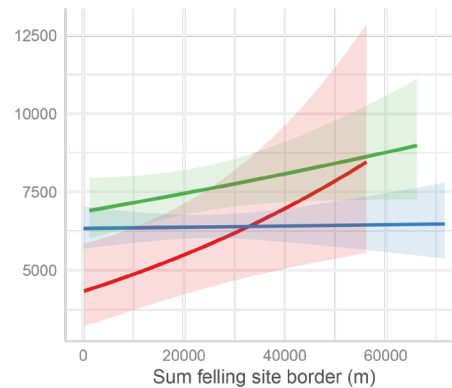
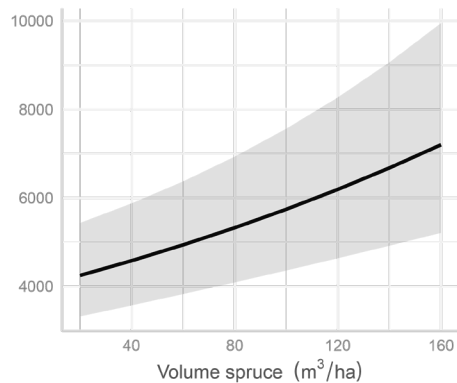
*Time lag for climatic variables and sum felling site border:*



**Models with three year lag perform best**

Predictor	Time lag (years)	P	$\Delta$ AIC
New felling site boarder	0	0.535	
	1	0.059	2.92
	2	0.099	2.11
	3	0.037	3.65
Seasonal temperature	0	<0.001	
	1	<0.001	-1.8
	2	<0.001	38.54
	3	<0.001	45.58
Seasonal precipitation	0	0.214	
	1	0.823	-1.46
	2	0.505	-1.09
	3	<0.001	16.13
Seasonal soil moisture	0	0.001	
	1	0.013	-4.23
	2	<0.001	27.35
	3	<0.001	79.61

# Most parsimonious model



# Conclusions

***Under **non-outbreak conditions**, local population size is associated with:***

- Productive volume spruce
- Sum felling site border (3 year lag)
- Temperature (3 year lag)
- Soil moisture (3 year lag)

***Caveat:***

***Norwegian populations are under the outbreak threshold – during epidemic phase, other associations may apply***

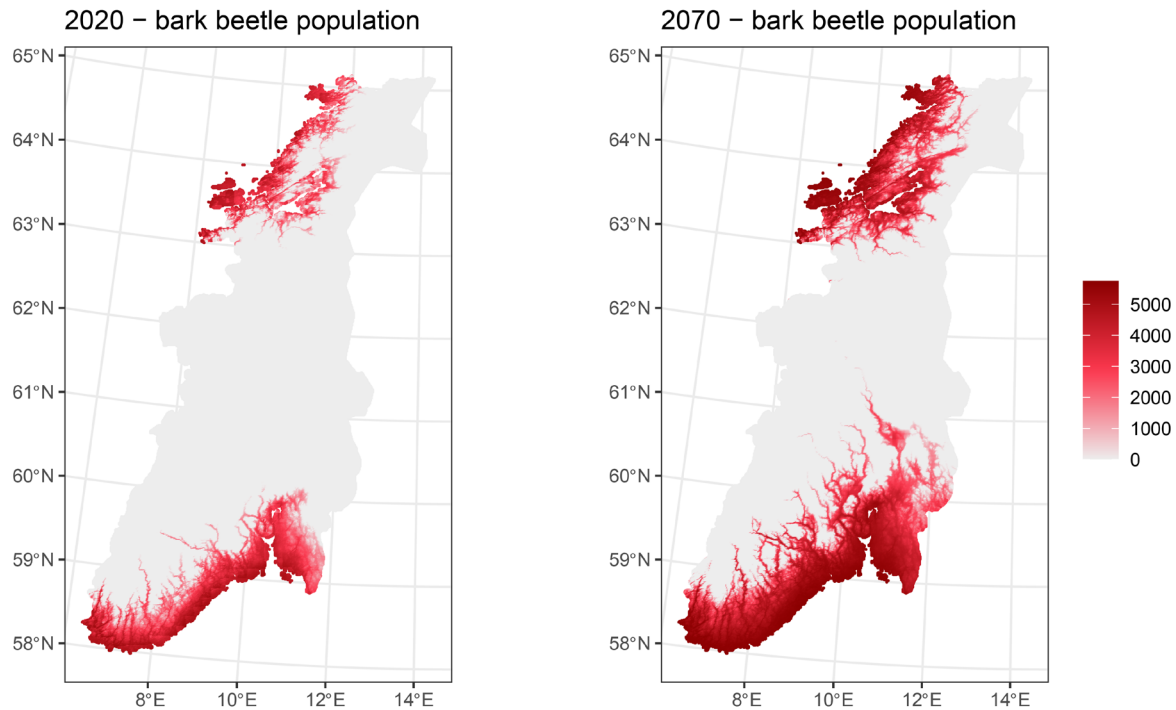
***Landscape factors and climatic conditions may bring population levels above outbreak threshold***



Aksel Granhus, NIBIO

# Future perspective

## *Future bark beetle population size with projected climate data and forest resource maps*



Thank you!



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Karsten Sund, NHM