Drones and satellites for forest health monitoring in Finland and forecasting cross-border outbreaks

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How we can map potential areas using MS-NFI? Spruce bark beetle

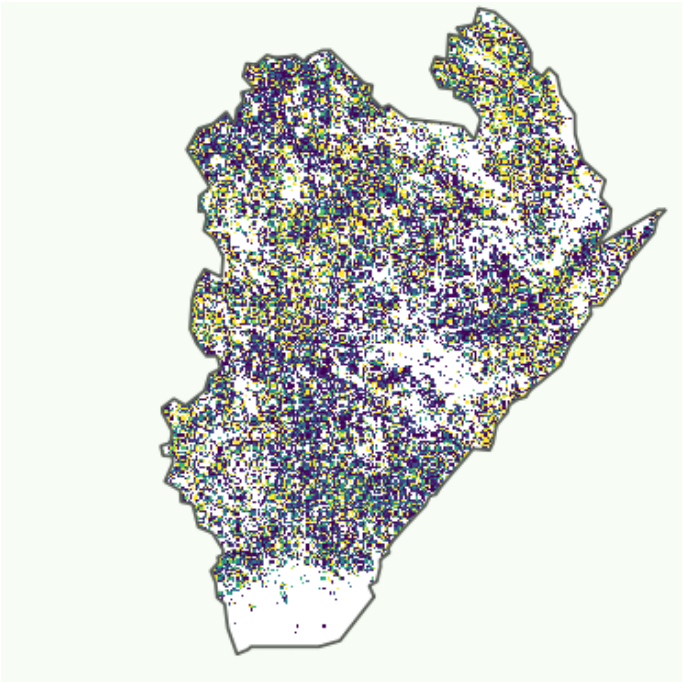
Extract from the MS-NFI forest resource data: Threat for Insect damage by spruce bark beetle (*Ips typographus*)

Likelihood of damage is expected to be increased on locations where (as a suggestion):

- spruce volume > 200 m^3/ha
- spruce age > 60

-> Simple raster algorithm provides straight forward, coarse identification of locations to keep an eye on

-> Can be maintained as new raw data is availlable, time series option, simple modeling framework



Challenges in future forest health monitoring

- Warming climate: damage risks will increase (for ex. current sitiation in Central Europe)
- Forest management practices in Russia: «the myth of unlimited forest resources»
- International trade brings unwelcome species: early detection of harmful alien species
- Scale
    - Spatial: from one tree to whole country
    - Temporal: from days to long-term trends
- How to overcome the challenges using new technologies?
    - Drones
    - Satellites
    - Artificial intelligence
    - Big Data

Innoforestview project 2019-2020

CBC 2014-2020
SOUTH-EAST FINLAND - RUSSIA

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UAV method development for high resolution mapping

Tree species	Theme	Crown property investigated	Location of experimental area	Timing
Spruce *(Picea abies)*	Root rot, *Heterobasidion parviporum*	Crown roundness, diameter, transparency (needle loss), needle color	Punkaharju, on-going experiment	On-going from 2019 and continues 2020 depending on results
Spruce *(Picea abies)*	Spruce bark beetle, *Ips typographus*	Needle color, drought induced changes in needles,	Punkaharju, additionally new campaign in planning, location to be decided	On-going from 2019 and continues until 2020
Birch *(Betula pendula)*	Damage by cerambycidae & buprestidae + vectored fungi	Spectral reflectance of "healthy" and "manipulated" trees and leaves.	Punkaharju	On-going from 2019 and continues until 2020
. Pinus sylvestris	Pine shoot beetles,*Tomicus piniperda* & *T. minor*	Abundance of shoots within the top part of the tree crown	Ylämylly terminal	Carried out in 2020

Test areas

1) ICP Level 2 Spruce plot area

- Mature spruce stand, tree specific in situ data, history included
- Root rot and bark beetle observations
- Experiment for capturing and classifying crown shape from 3-D canopy model

2) Experiment with girdled spruce trees

- Trees healthy to start with, but standing on location where attack from bark beetles is likely
- Manipulation
- Monitoring of crown development by remote sensing

3) Birch manipulation area A

- Trees healthy to start with
- Simulated beetle attack, tree manipulation and follow up of crown condition by remote sensing

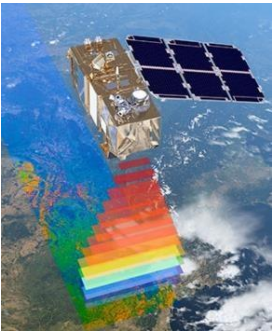
4) Birch manipulation area B

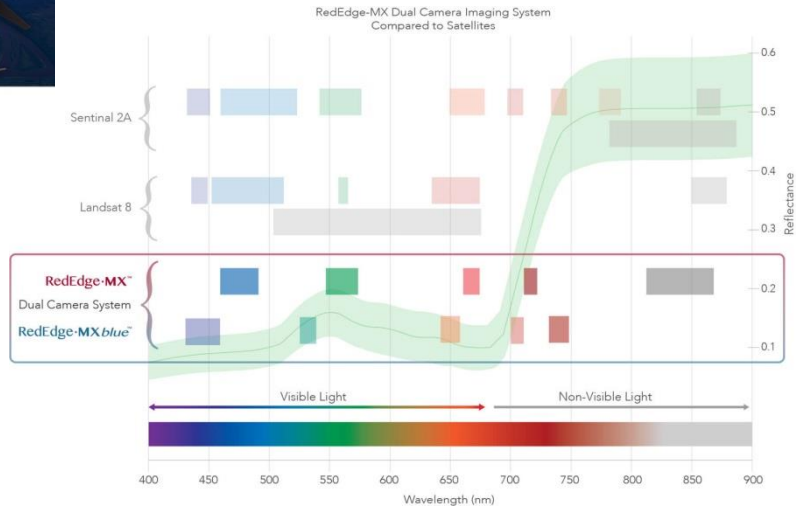
- *Trees healthy to start with*
- *Not manipulated in 2019*

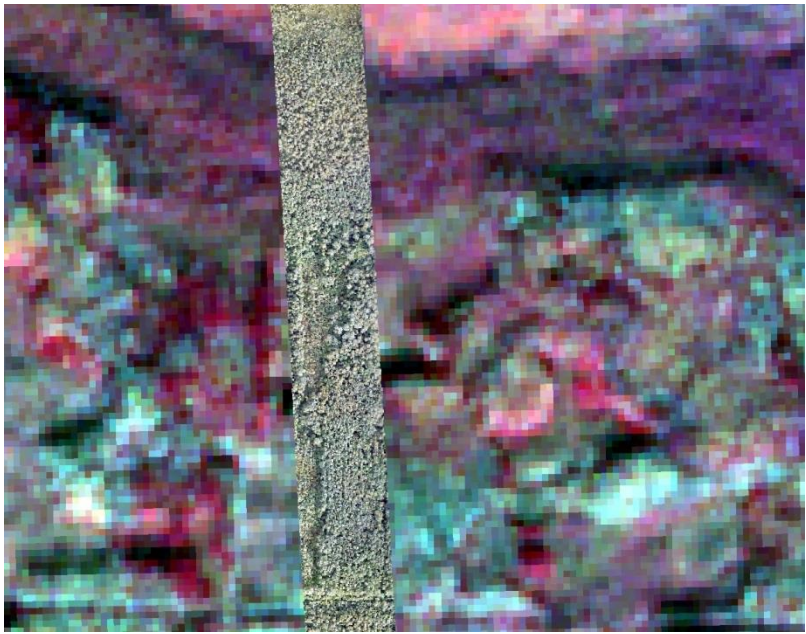
UAV method development

Research questions:

- 2019-2020: How to detect forest diseases or insect attacks **before losing the wood value**?
- 2020: How to detect **forest diseases at large areas** using medium resolution (10 m) high frequency (weekly) multispectral satellite data?





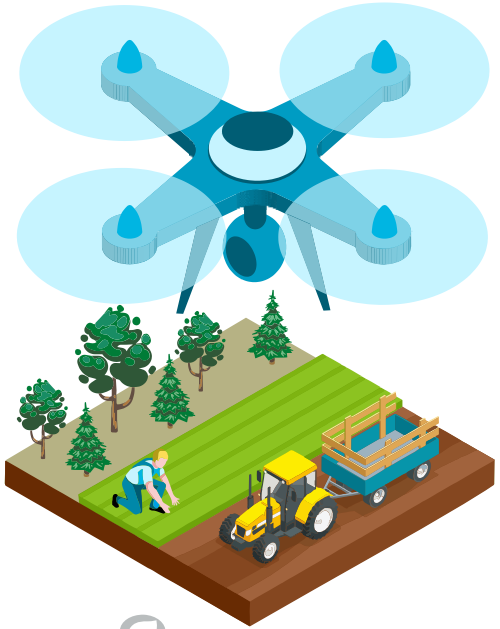


Solution: to combine clouds and drones with know-how

Drones

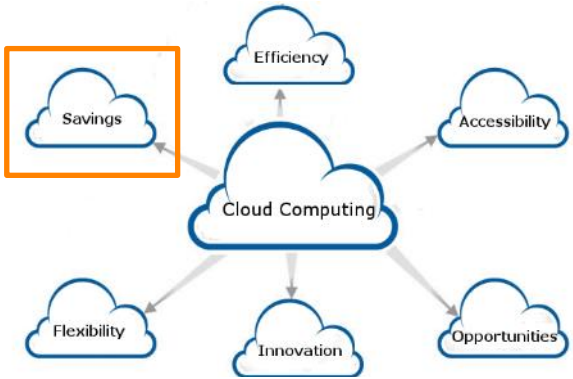
How to fly to get **health status of the trees**?

2. How to improve the **accuracy of drone based health status assessment**?



Clouds

1. Cost and speed of data processing
2. Commercial clouds vs. own infrastructure



Microsoft Azure

aws

CSC

Algorithms

1. Tree-wise forest management inventory, altitude: 80 – 120 m
2. Identification of the health status of the trees

Standard aerial imaging processing: GNSS data post processing, triangulation, point cloud, DEM, DSM, orthophoto, 3D model

Artificial intelligence combined with **field data**: training sets, test sets, quality control

Trees, health status

Metashape

Pix4Dmapper

Bentley Advancing Infrastructure

OpenDroneMap

Luke LUONNONVARAKESKUS

Accuracy of consumer drones

Drones from the shop

1599 €

1499 €

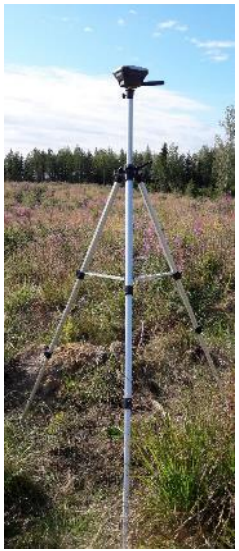
399 €

Positional error (x, y): 0.2 – 3 m

Positional error (z): **3 – 6 m**

Seedlings counting, lichens, mushrooms, berries

Improved consumer drones



243 €

Positional error (x, y): 0.02

Positional error (z): **0.05 m**

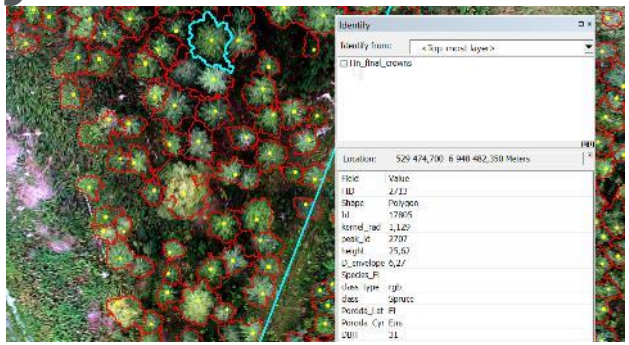
Tree-wise forest inventory, measuring heights and volumes

Tree-wise forest management inventory

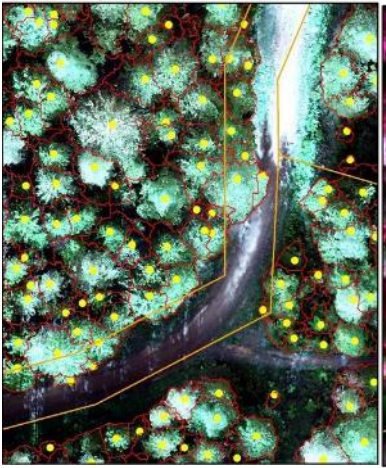
Drones with high precision GPS and multispectral cameras

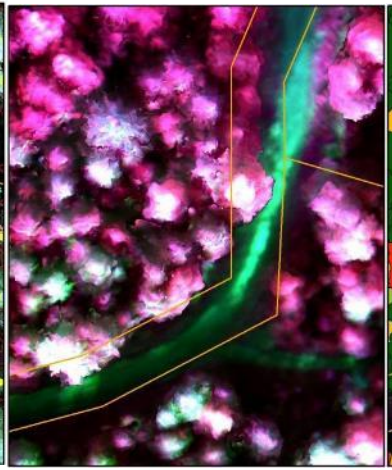
Accuracy:

- Tree detection: 96%
- Tree height: 0.05 – 0.15 m
- Species recognition: 90%
- DBH: 2 cm

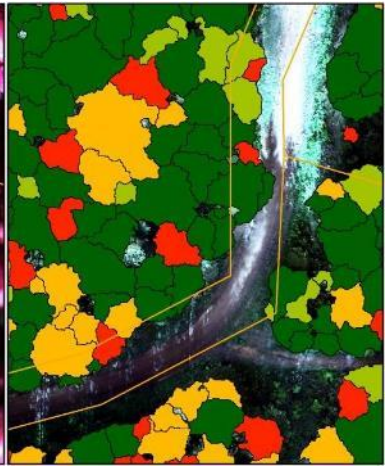


Results from data processing platform

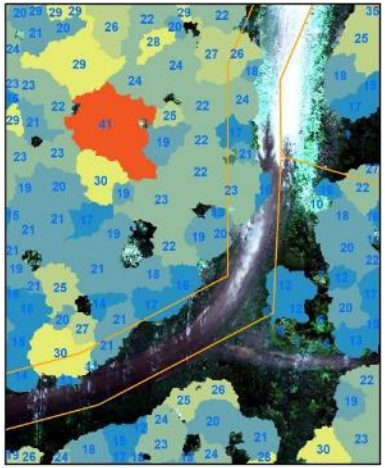




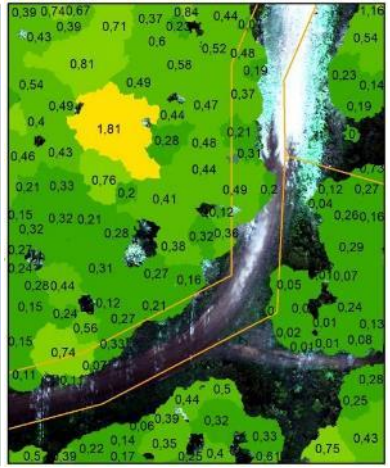
Orthophoto in RGB and NIR, 3 D model, crown boundaries, tree height



Species



Diameters at breast height

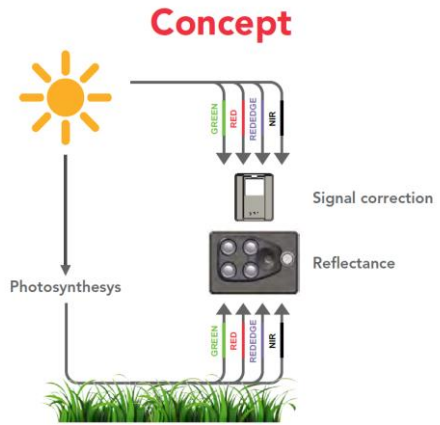


Volume, m3, carbon amount, kg

Drone prototype for early detection of forest damage in 2019

- 3 bands in visual range (RGB)
- 2 bands in RedEdge and NIR

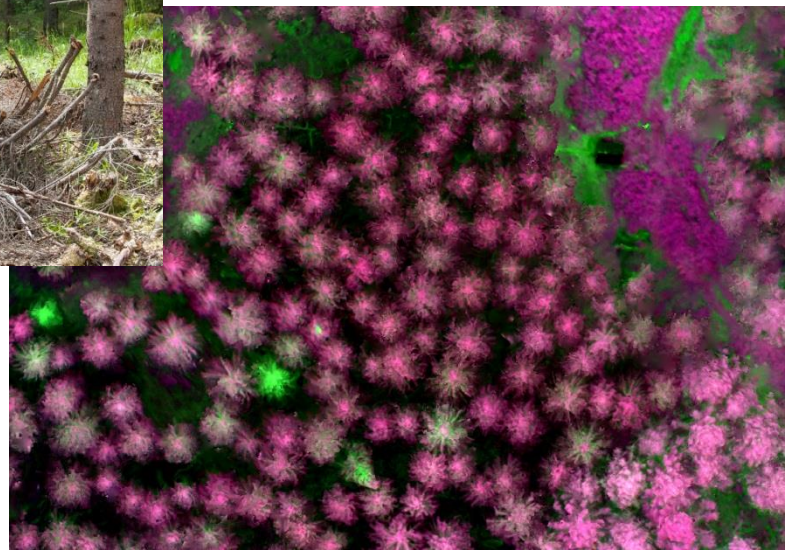
Modified Phantom + GNSS base station



UAV method development – *Picea abies* 1/2

Punkaharju experimental site

- Root rot, *Heterobasidion parviporum*
- Crown roundness, diameter, transparency (needle loss), needle color



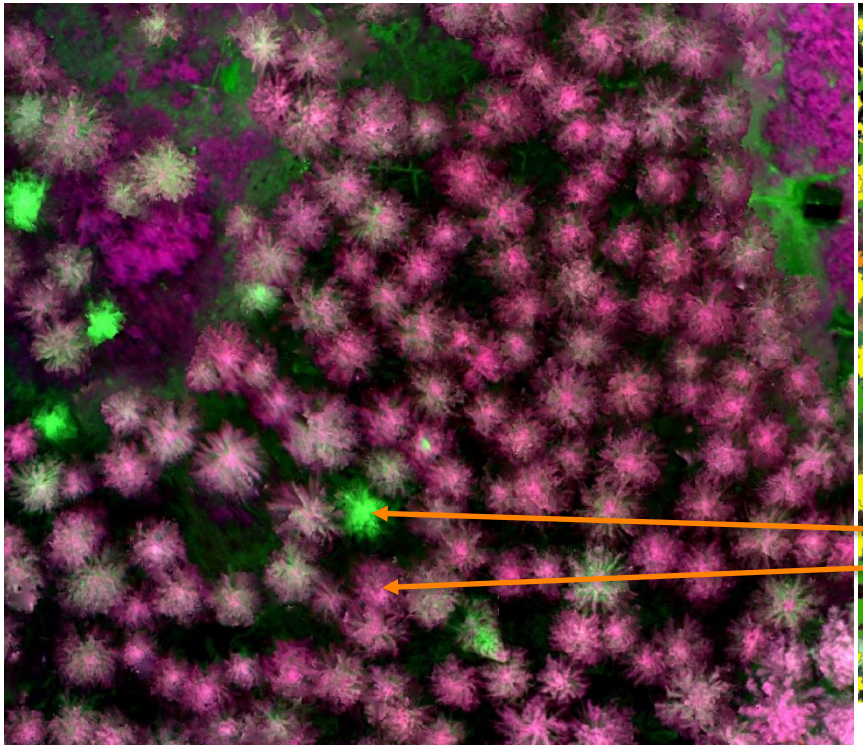
UAV method development – *Picea abies* 2/2

Punkaharju experimental site

- Spruce bark beetle, *Ips typographus*
- Gridling manipulation
- Attack initiation by pheromone baiting the trees

UAV method development – *Picea abies*

- Root rot,
- Heterobasidion annosum
- Crown roundness, diameter, transparency (needle loss), needle color



Red – damaged
Yellow – potentially damages
Green - healthy

UAV method development – *Betula pendula*

Mimicing damage by cerambycidae & buprestidae + vectored fungi

e.g. quarantine species (not present in Finland) Asian longhorned beetle (*Anoplophora glabripennis*) and bronze birch borer (*Agrilus anxius*)

Spectral reflectance of ”healthy” and ”manipulated” trees and leaves

Support from leaf spectrometry

Punkaharju experimental site

Mimicing non-native aliens

Anoplophora glabripennis, Asian longhorned beetle

Agrilius anxius, birch bronze borer

VIS + NIR by drone before and after damage

Leaf spectra recorded both before treatment and after one month

InnoForestView

UAV method development – *Betula pendula*

UAV method development – *Pinus sylvestris* 2020

Pine shoot beetle

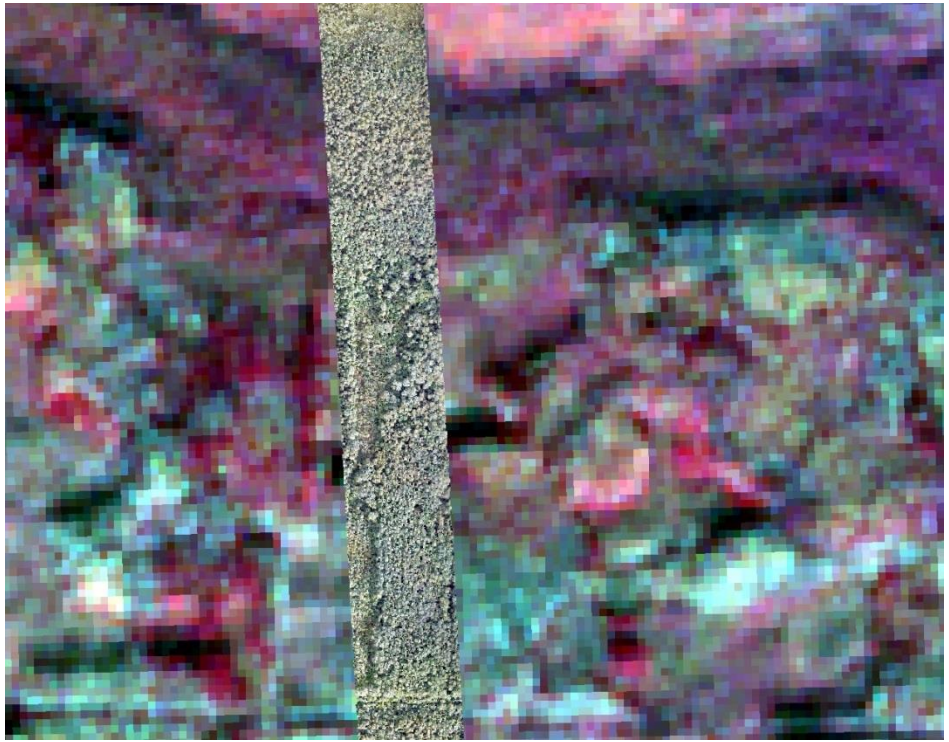
Tomicus piniperda & *T. minor*

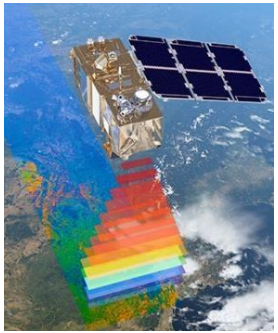
Beetle larvae live in sawlogs stored in terminals and adults feed in the shoots of nearby trees.

Abundance of shoots within the top part of the tree crown

place TBC

Conducting data fusion and algorithm development for producing thematic maps



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