

Identification of Tree Species of Individual Trees by Combining Very High Resolution Laser Data with Multi-Spectral Images

Å Persson^a, J Holmgren^b, U Söderman^a

^a Department of Laser Systems,
Swedish Defence Research
Agency, Linköping, Sweden

^b Department of Forest Resource
Managements and Geomatics,
Swedish University of Agricultural
Sciences, Umeå, Sweden

Objectives

- Identify tree species of individual trees (Norway spruce, Scots pine, deciduous trees) through combining features of high resolution laser data with high resolution multi-spectral images
 1. Delineation of single tree crowns (laser data)
 2. Estimation of tree attributes (laser data)
 3. Classification of tree species (laser data+aerial images)

Material

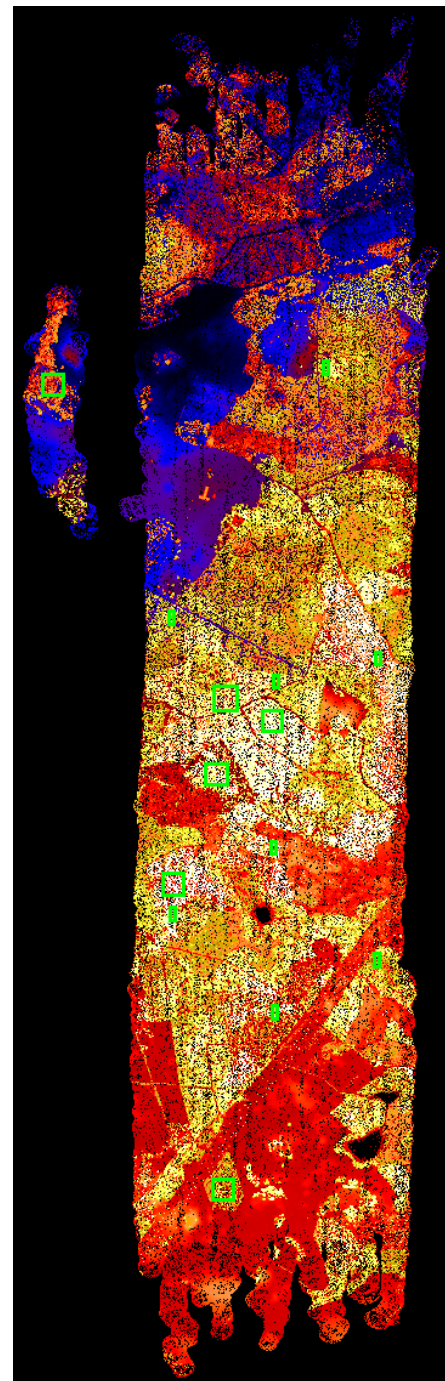
Test site in southern Sweden

Laser data

- System: TopEye Mk II
- Date: August 2004
- Flight height: 130 m
- Wavelength: 1064 nm
- Pulsing frequency: 50 kHz
- Pulse length: 5 ns
- Beam divergence: 1 mrad
- Point density: 50 points/m²

Field data

- 14 plots (50x20 or 80x80 m²)
- Norway spruce (six plots)
- Scots pine (six plots)
- Deciduous (two plots)
- Tree position
- Stem diameter
- Tree species
- Tree height (sample trees)
- Crown base height (sample trees)



Multi-spectral images

Z/I Digital Mapping Camera (DMC)

Four panchromatic images ->
single high resolution image (PAN)

Three multi-spectral cameras (CIR image)

- B1 (500-560 nm)
- B2 (590-675 nm)
- B3 (675-850 nm)

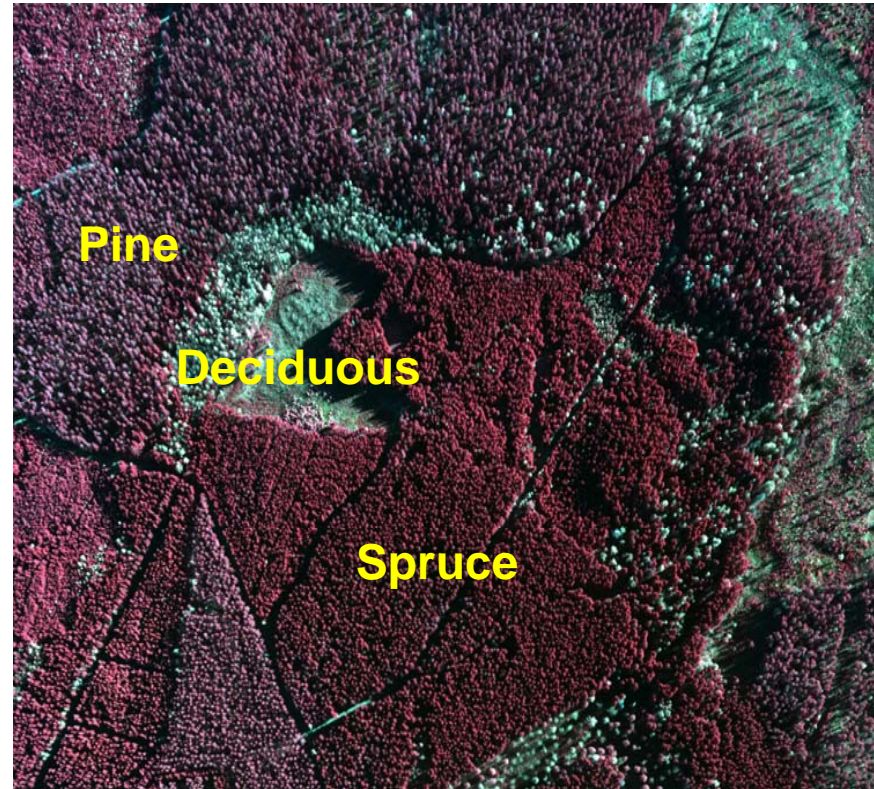
High resolution PAN image (0.1 m)

Lower resolution CIR image (0.6 m)

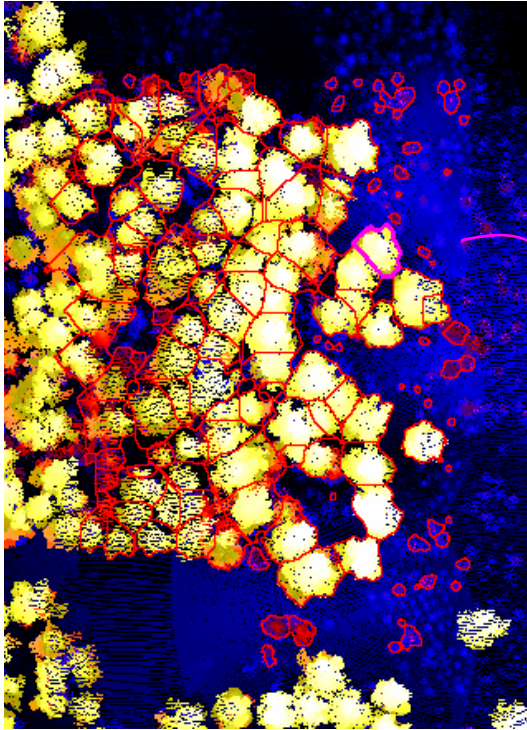
Two sets of images: October 2003

June 2005

Flight altitude: 1200 m

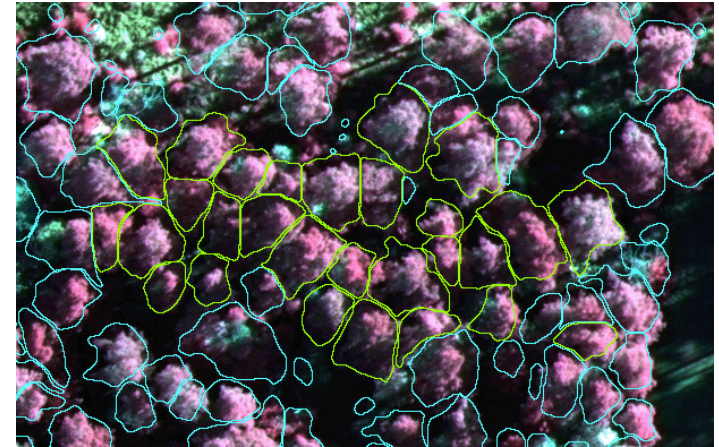


Method



Laser data

mapping of
crown
segments



Multi-spectral image
(not orthorectified)

1. Delineation of single tree crowns

2. Estimation of tree attributes

- tree height
- crown, stem diameter
- timber volume

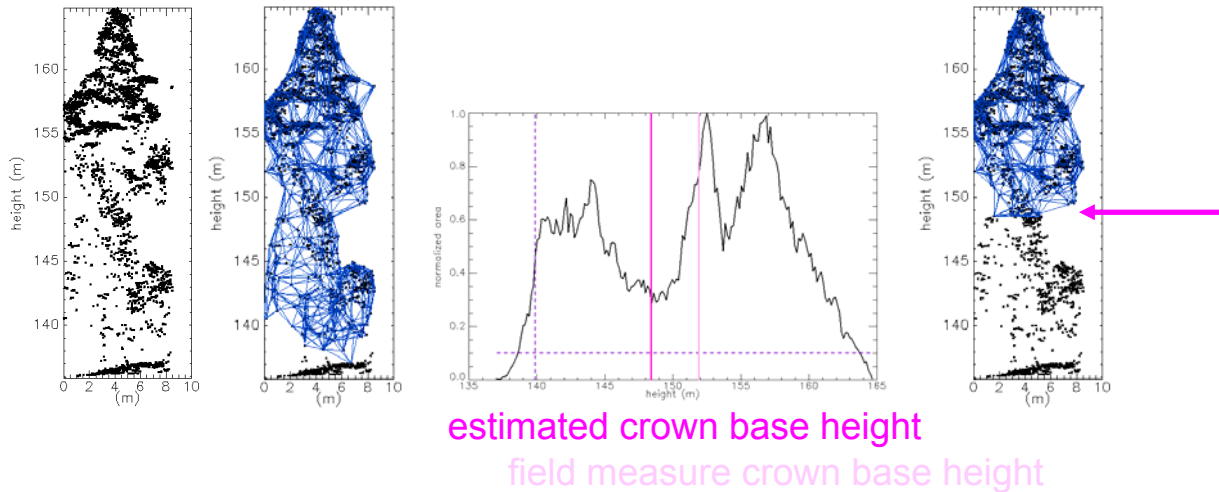
3. Classification of tree species

through combining features from

- laser measurements
- multi-spectral images

Features – laser data

Estimation of crown base height

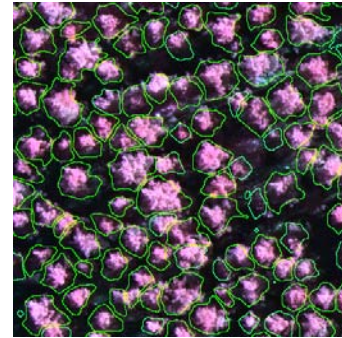


- Approximate shape of trees using Alpha Shapes ($\alpha=1.5$ m)
- Derived from Delaunay triangulation
- Minimum area -> estimated crown base height

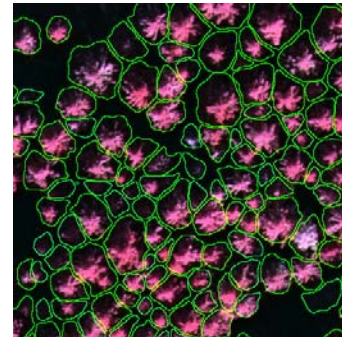
- height distribution
- proportion of different pulse types
- canopy shape
- intensity of returns
- clustering of returns

Features - multi-spectral images

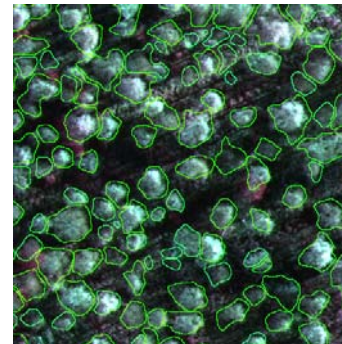
- spectral mean values from the three bands



Pine

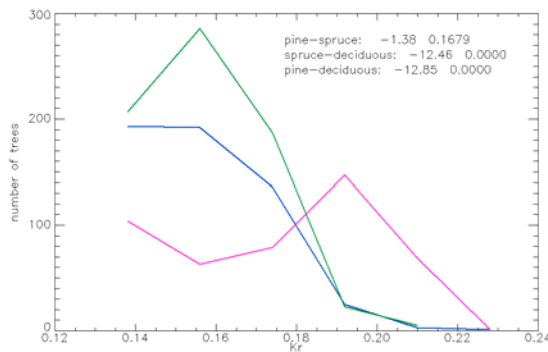
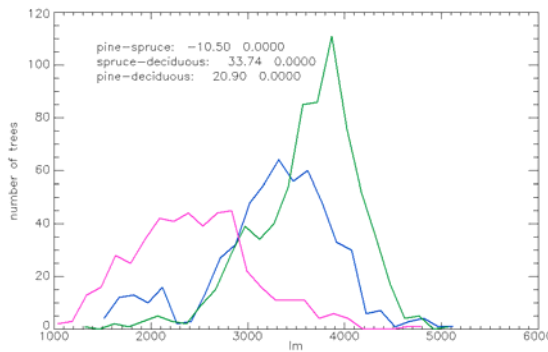
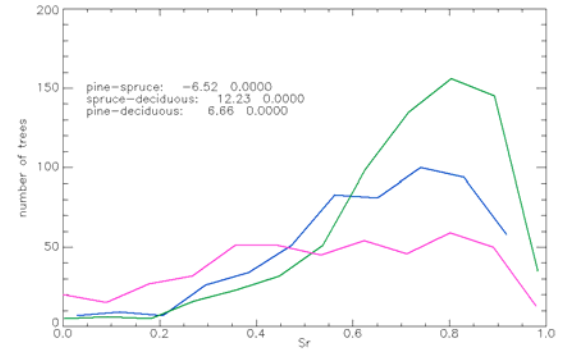
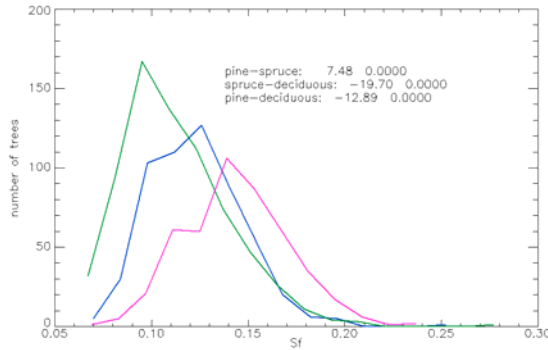
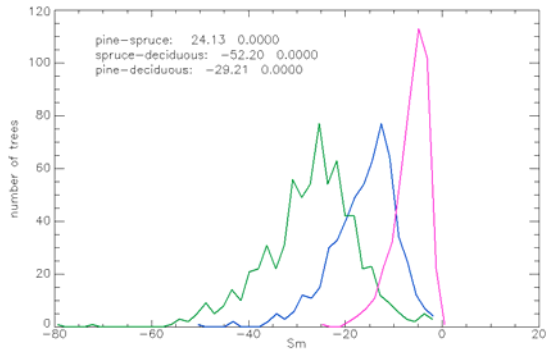
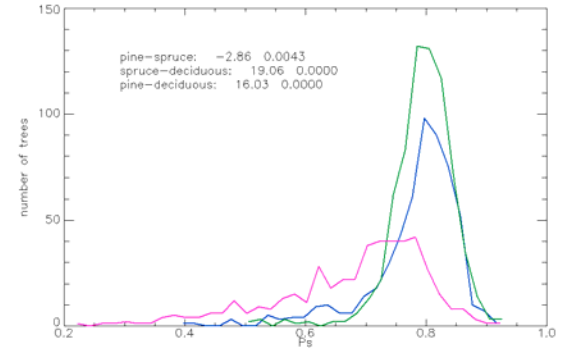
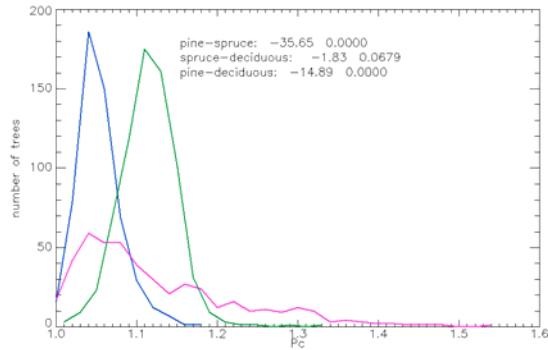
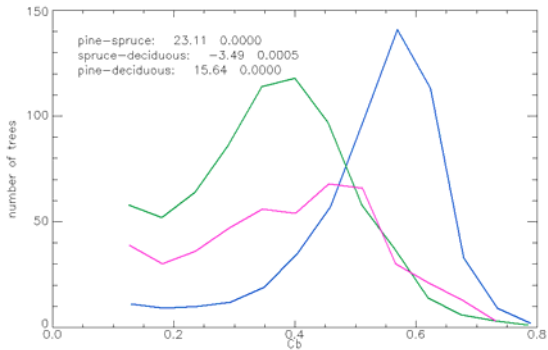


Spruce



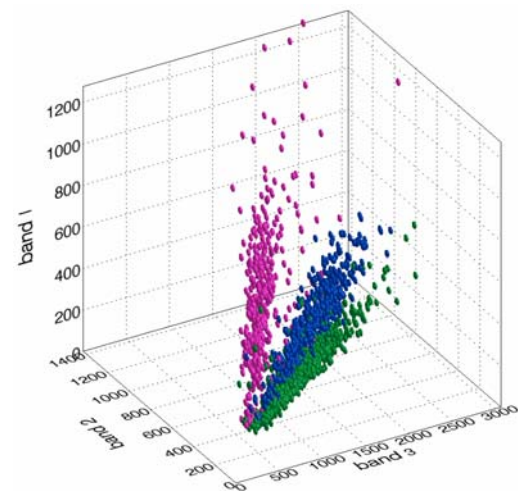
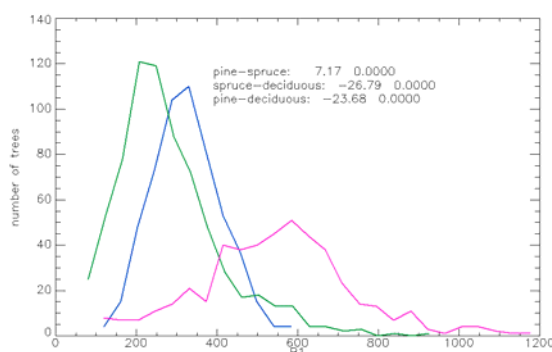
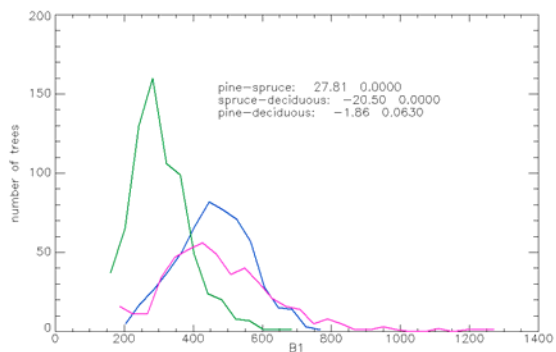
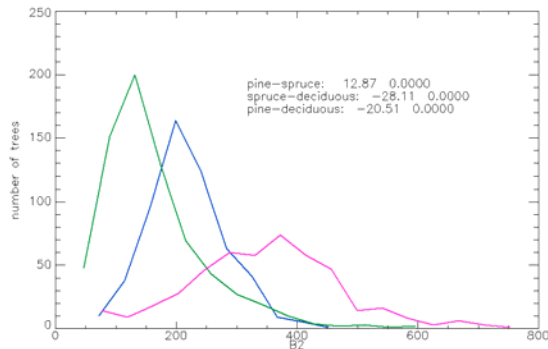
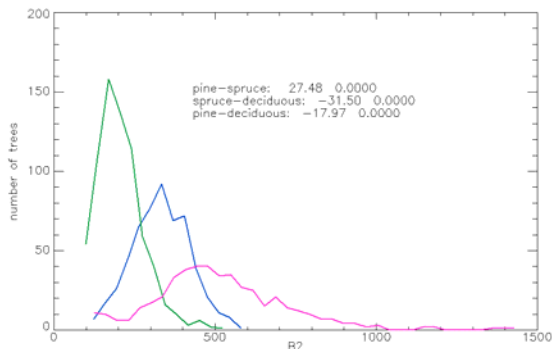
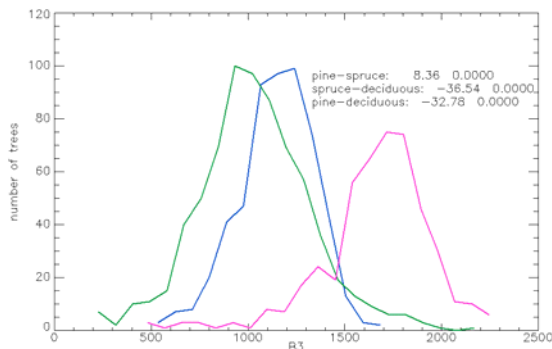
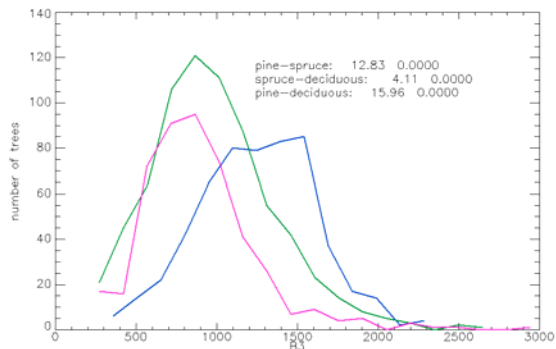
Deciduous

Laser variables

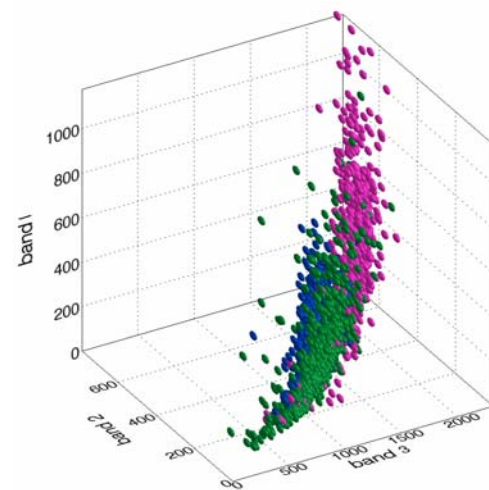


pine
 spruce
 deciduous

Multi-spectral variables



Autumn



Summer

Autumn

Summer

pine
 spruce
 deciduous

| Laser | | | | |
|--------------------|-------------|--------|-----------|--------------|
| Classified | True groups | | | |
| | Pine | Spruce | Deciduous | Total |
| Pine | 482 | 58 | 56 | |
| Spruce | 34 | 628 | 15 | |
| Deciduous | 34 | 22 | 392 | |
| Proportion correct | 0.876 | 0.887 | 0.847 | 0.873 |

| DMC_{autumn} | | | | |
|-----------------------------|-------------|--------|-----------|--------------|
| Classified | True groups | | | |
| | Pine | Spruce | Deciduous | Total |
| Pine | 480 | 42 | 9 | |
| Spruce | 64 | 652 | 22 | |
| Deciduous | 6 | 14 | 432 | |
| Proportion correct | 0.873 | 0.921 | 0.933 | 0.909 |

| DMC_{summer} | | | | |
|-----------------------------|-------------|--------|-----------|--------------|
| Classified | True groups | | | |
| | Pine | Spruce | Deciduous | Total |
| Pine | 458 | 83 | 29 | |
| Spruce | 60 | 563 | 23 | |
| Deciduous | 32 | 62 | 411 | |
| Proportion correct | 0.833 | 0.795 | 0.888 | 0.832 |

| Laser + DMC_{autumn} | | | | |
|-------------------------------------|-------------|--------|-----------|--------------|
| Classified | True groups | | | |
| | Pine | Spruce | Deciduous | Total |
| Pine | 520 | 23 | 6 | |
| Spruce | 25 | 672 | 12 | |
| Deciduous | 5 | 13 | 445 | |
| Proportion correct | 0.945 | 0.949 | 0.961 | 0.951 |

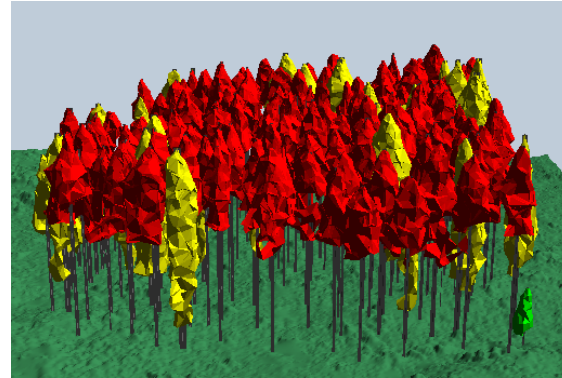
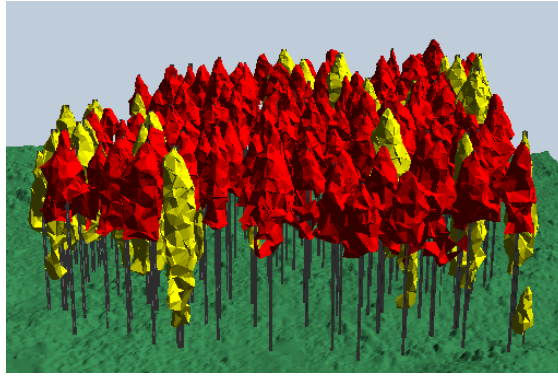
| Laser + DMC_{summer} | | | | |
|-------------------------------------|-------------|--------|-----------|--------------|
| Classified | True groups | | | |
| | Pine | Spruce | Deciduous | Total |
| Pine | 502 | 34 | 15 | |
| Spruce | 34 | 665 | 16 | |
| Deciduous | 14 | 9 | 432 | |
| Proportion correct | 0.913 | 0.939 | 0.933 | 0.929 |

True

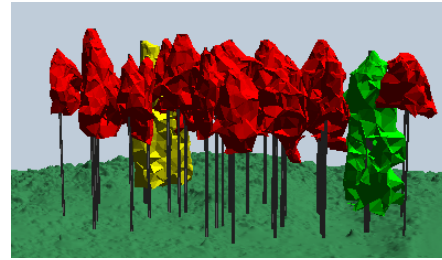
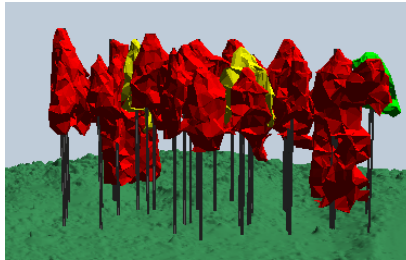
Classified

pine
spruce
deciduous

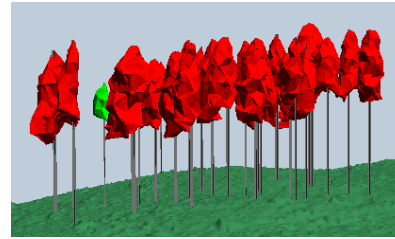
plot 1
(pine)



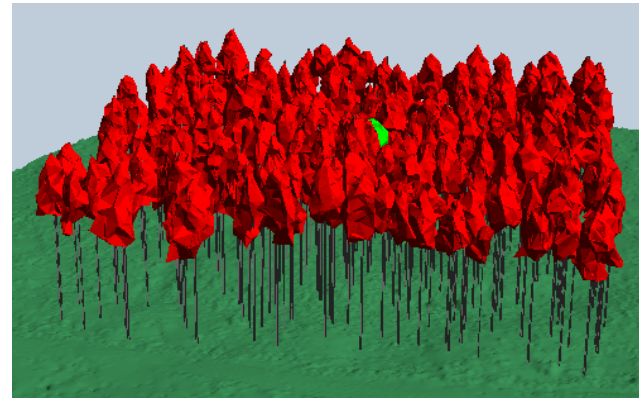
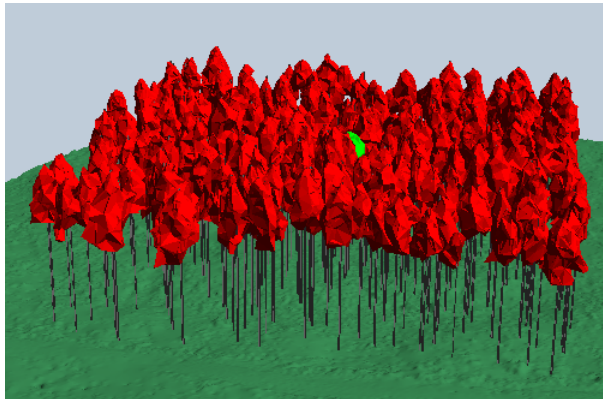
plot 2
(pine)



plot 3
(pine)



plot 5
(pine)

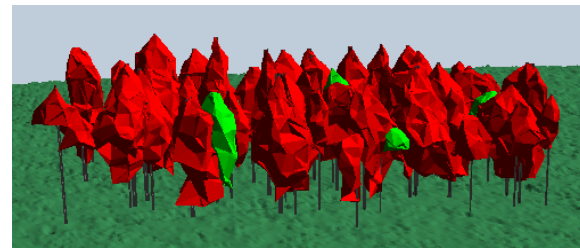
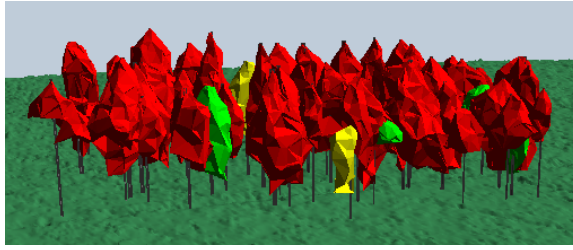


True

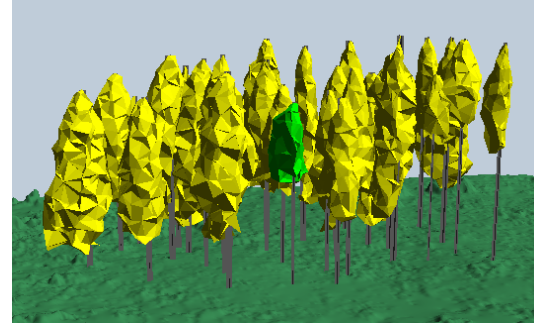
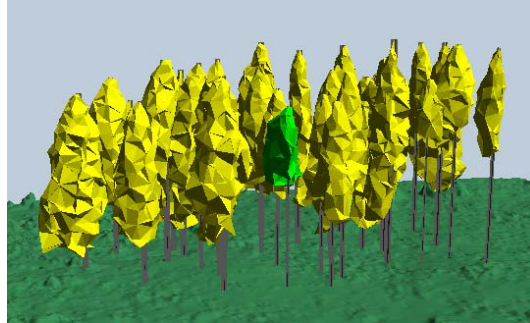
Classified

pine
spruce
deciduous

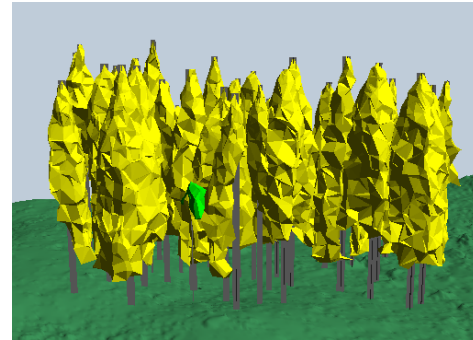
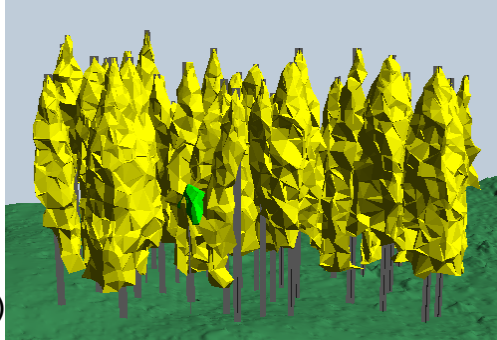
plot 6
(pine)



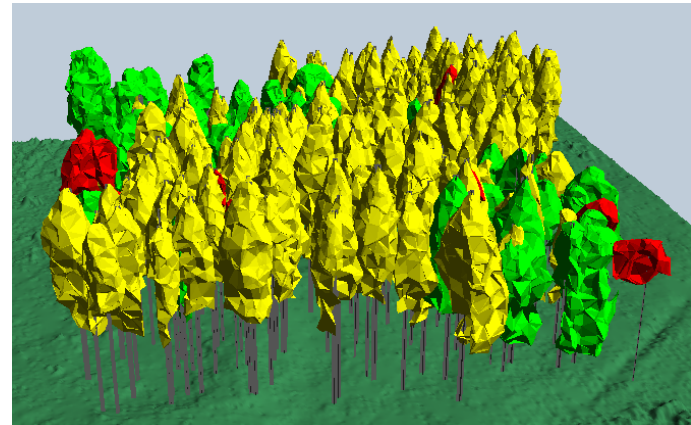
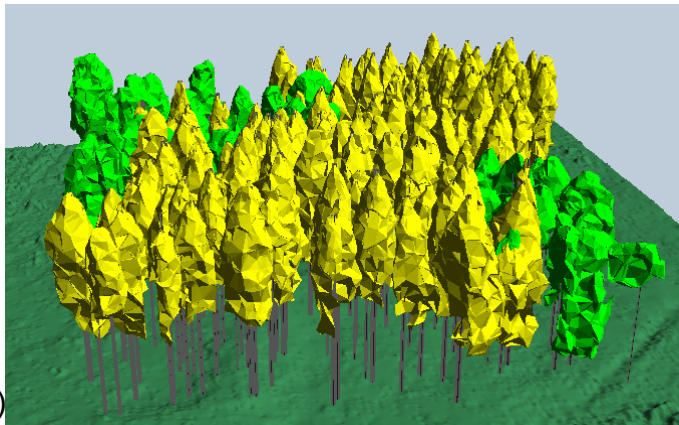
plot 7
(spruce)



plot 8
(spruce)



plot 9
(spruce)

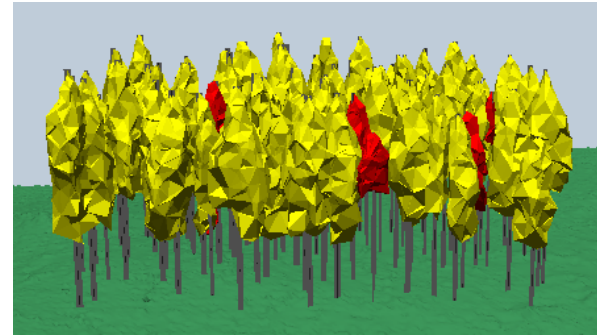
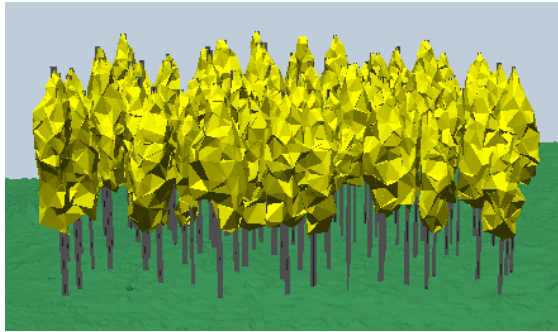


True

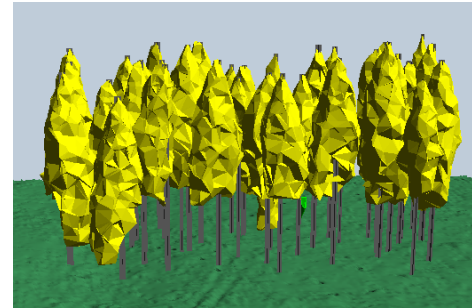
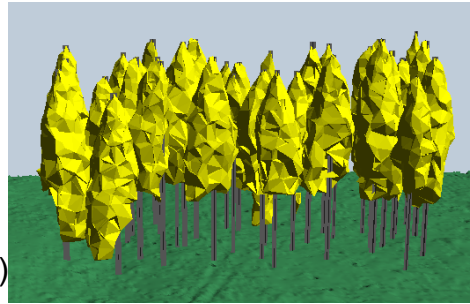
Classified

pine
spruce
deciduous

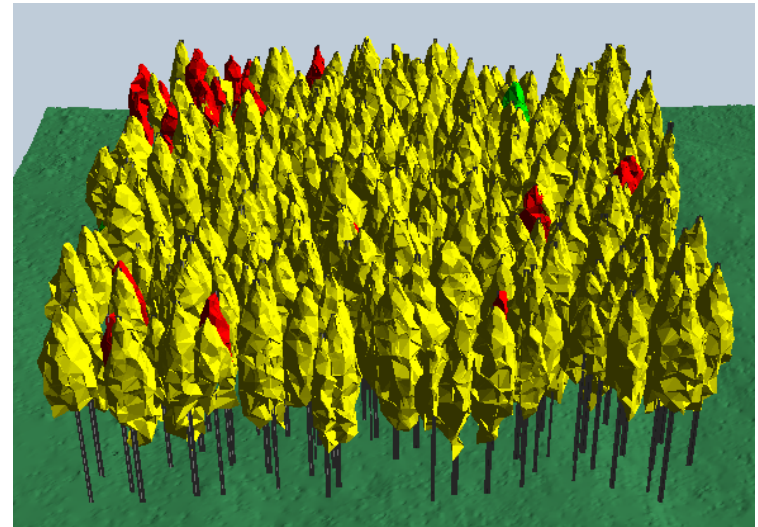
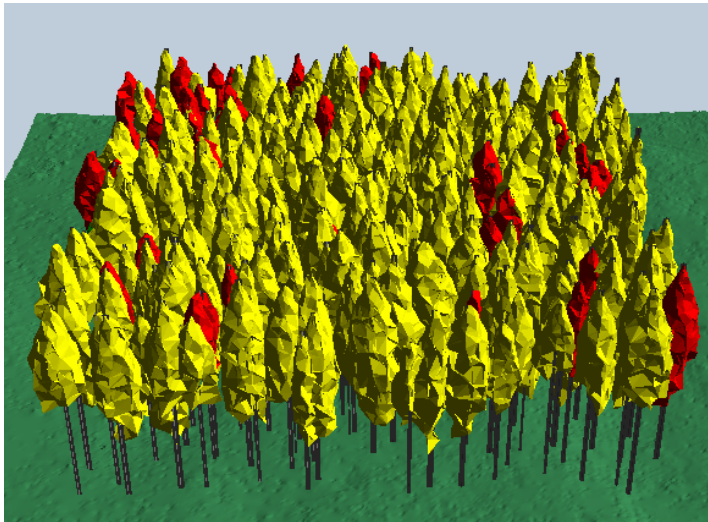
plot 10
(spruce)



plot 11
(spruce)



plot 12
(spruce)

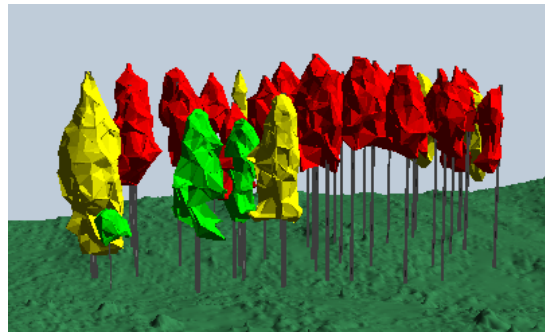
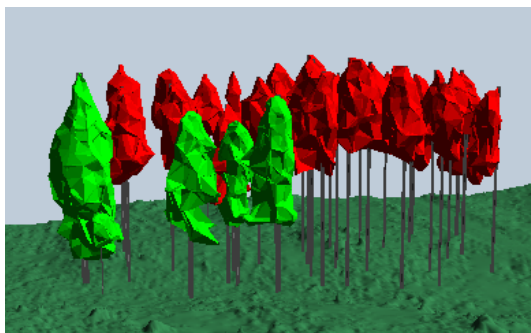


True

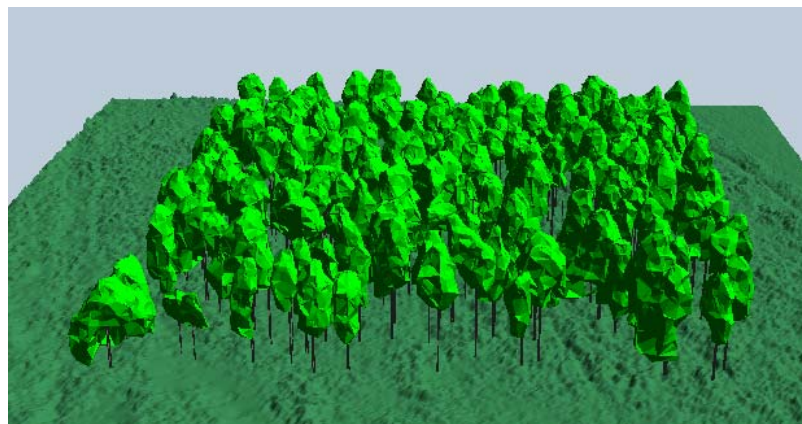
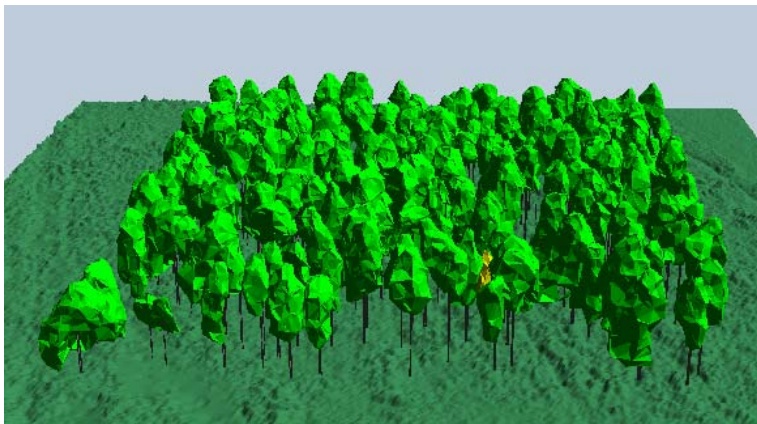
Classified

pine
spruce
deciduous

plot 13
(pine)



plot 14
(deciduous)



plot 15
(deciduous)

