



Influence of Forest Input Data on Rockfall Simulations at the Stand Level



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Jean-Mathieu MONNET,
Franck BOURRIER, David TOE
UR Mountain Ecosystems
Irstea Grenoble, FRANCE



Context: protective effect of forest against rockfall



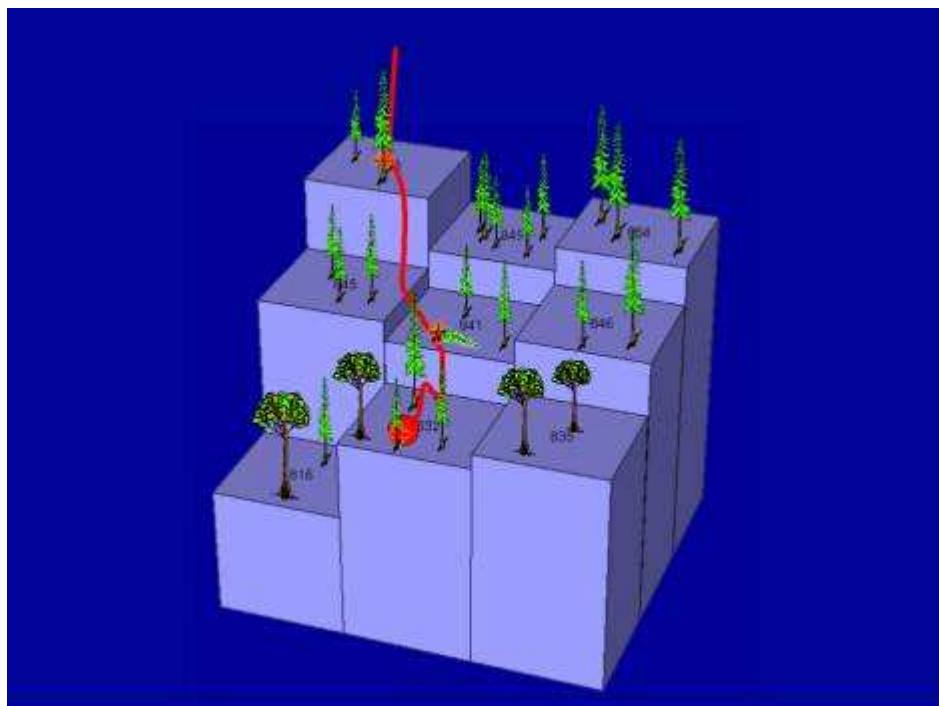
Damage on forest below the release point

Veyrier-du-Lac, (French Alps)
January, 20th 2009
~100 m³



Block stopped in the forest

Context: rockfall trajectory simulations take into account the forest effect



Scheme of trajectory simulation in RockyFor3D

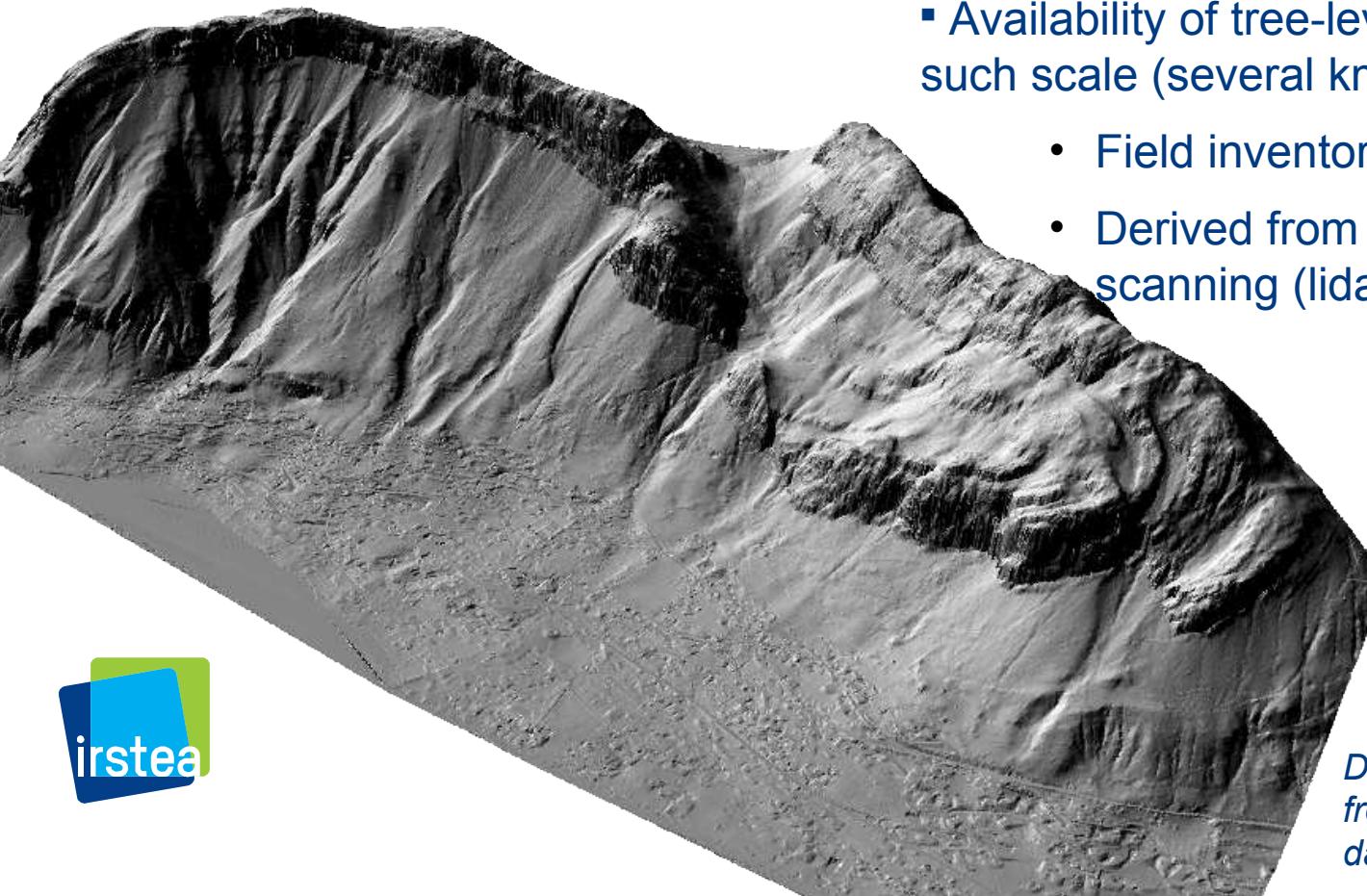
RockyFor3D software

- Terrain modelled as a raster map
- Spherical (not material) points with indirect accounting for rock shape
- Succession of free fall and rebound
- Impacts on trees located in the trajectory

Question : operational mapping of rockfall hazard

How to create the forest input data ?

- Interaction modelled at the tree level
- Availability of tree-level forest maps at such scale (several km²):
 - Field inventory (full, statistical)
 - Derived from airborne laser scanning (lidar)



Objective: compare the influence of different forest input data on rockfall simulations

At the stand level (0.25 – 1 ha)

- Tree-level ground truth not available at the operational scale
- Effect of different forest input data at small scale

On simulated terrain

- Remove terrain effect → only the influence of forest data

Comparison criteria

- Distribution of rockfall energies
- Number of passing blocks

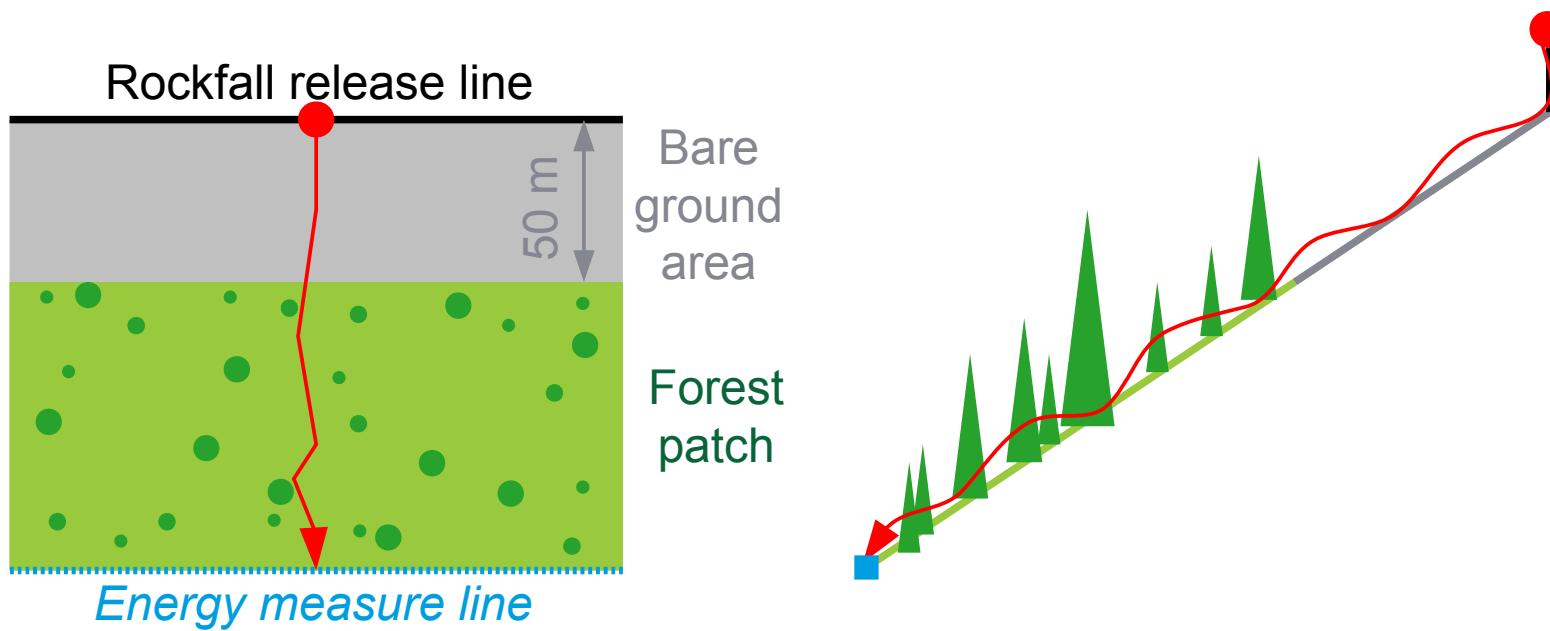
Emphasize limitations of rockfall simulations with forest data

- Due to characteristics/errors in the input data
- Due to the modelling/assumptions by the software

Methods: simulation parameters

Simulation parameters

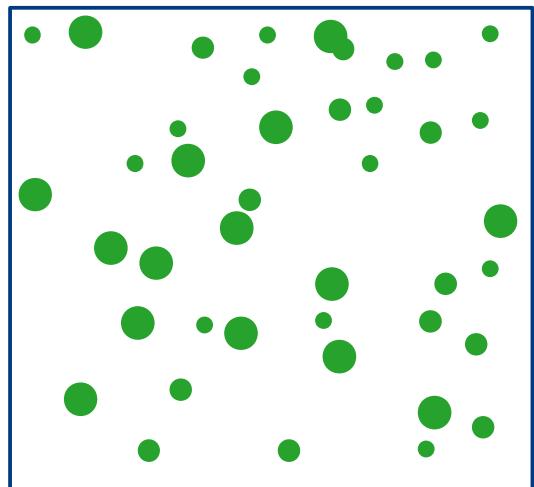
- Topography : simulated slope 35°
- Soil type 4 (compact soil with rock fragments), low rugosity
- Spherical blocks 1 m³, 2.6 t.m⁻³
- Release height release 5 m



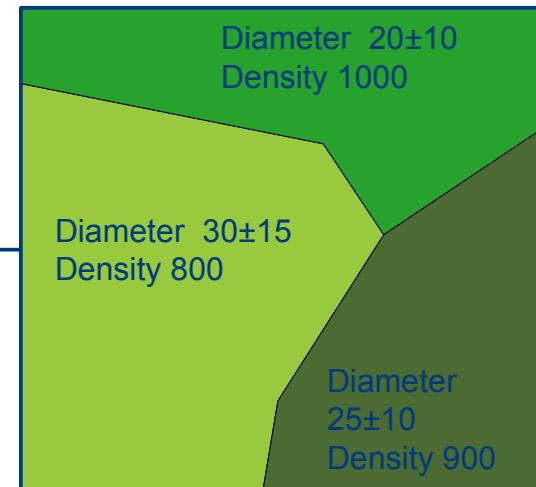
Methods: forest inputs

Forest inputs for RockyFor3D

- Raster file with percent of coniferous stems
- Tree positions and diameter
 - « treefile » directly supplied
 - Mean and sd of diameter distribution, and number of trees given for specific areas → treefile simulated.



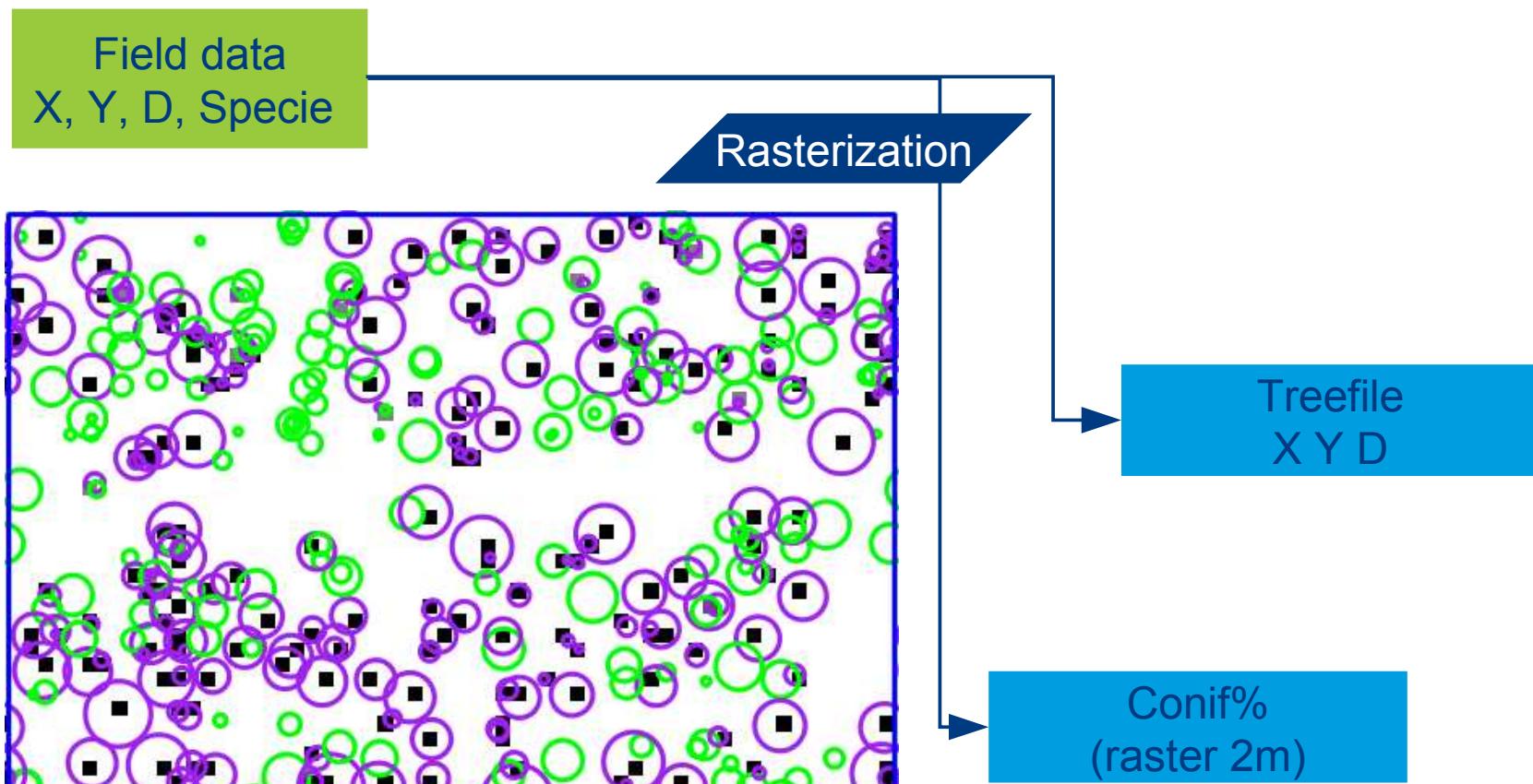
Treefile: tree-level input (X, Y, D)



Area-level input (X, Y, D)

Methods: forest inputs

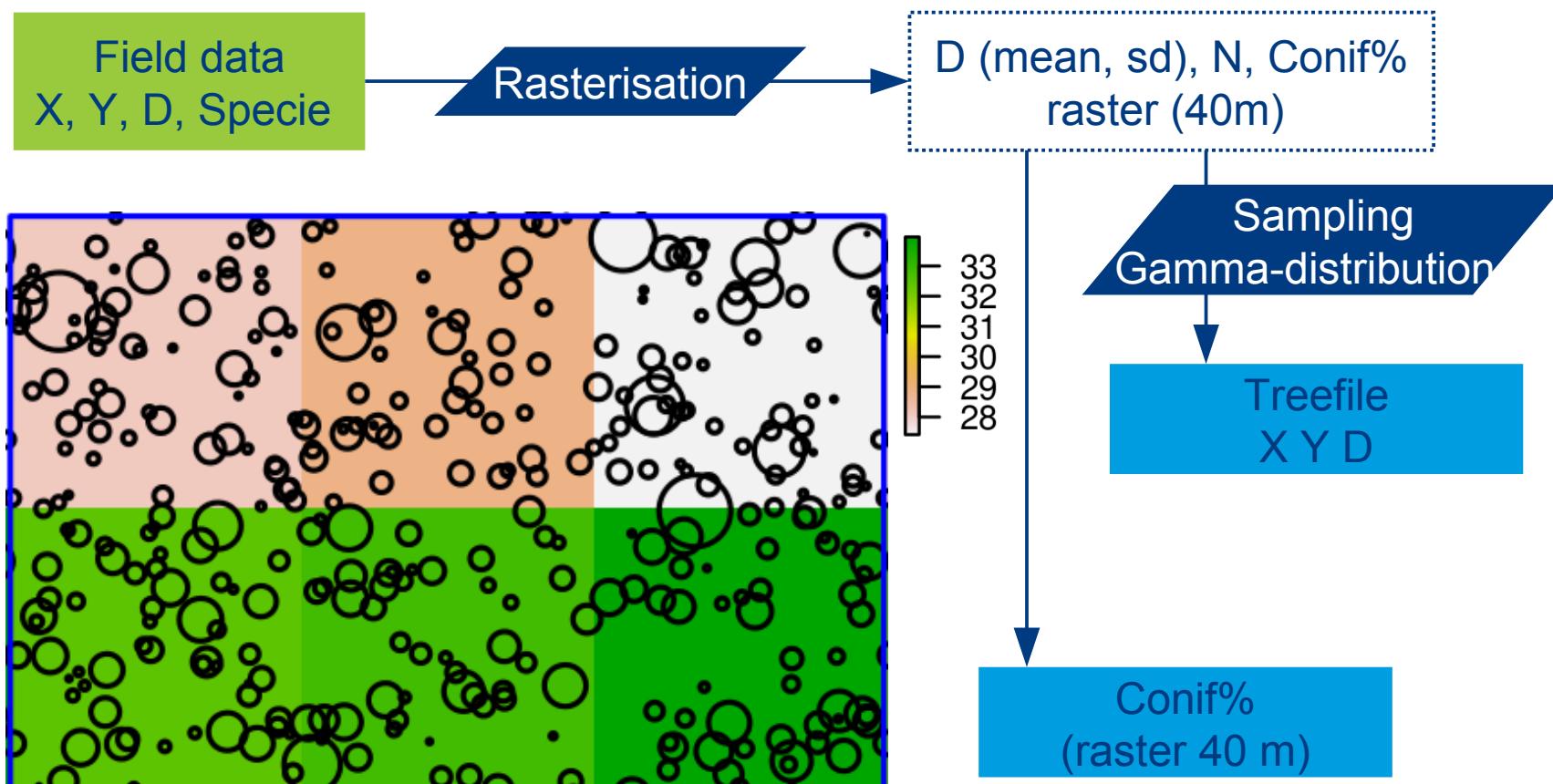
Full field inventory with tree positions (**FieldTree**)



Inventoried trees and rasterized coniferous percentage

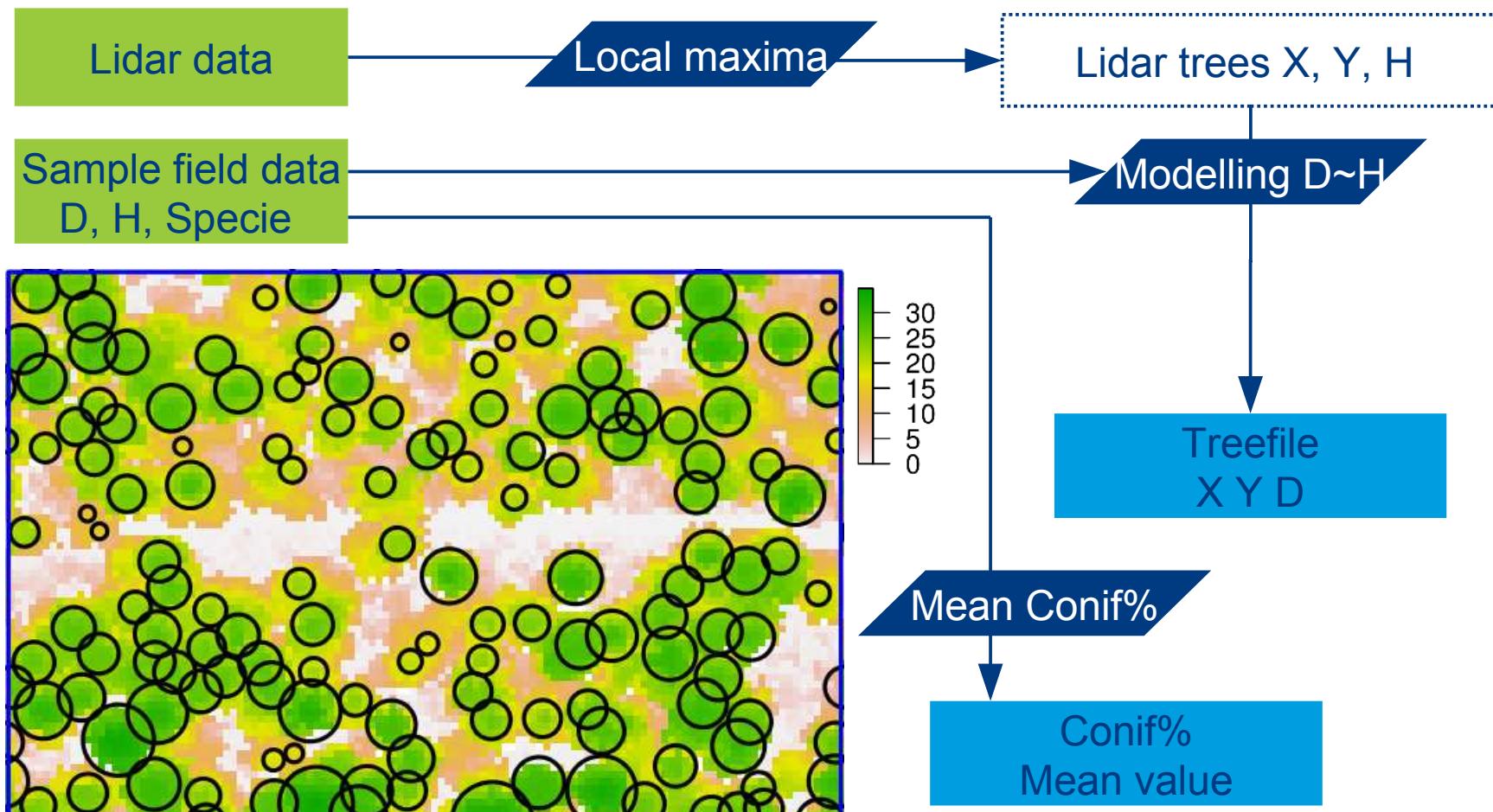
Methods: forest inputs

Area-based field inventory (**FieldArea**)



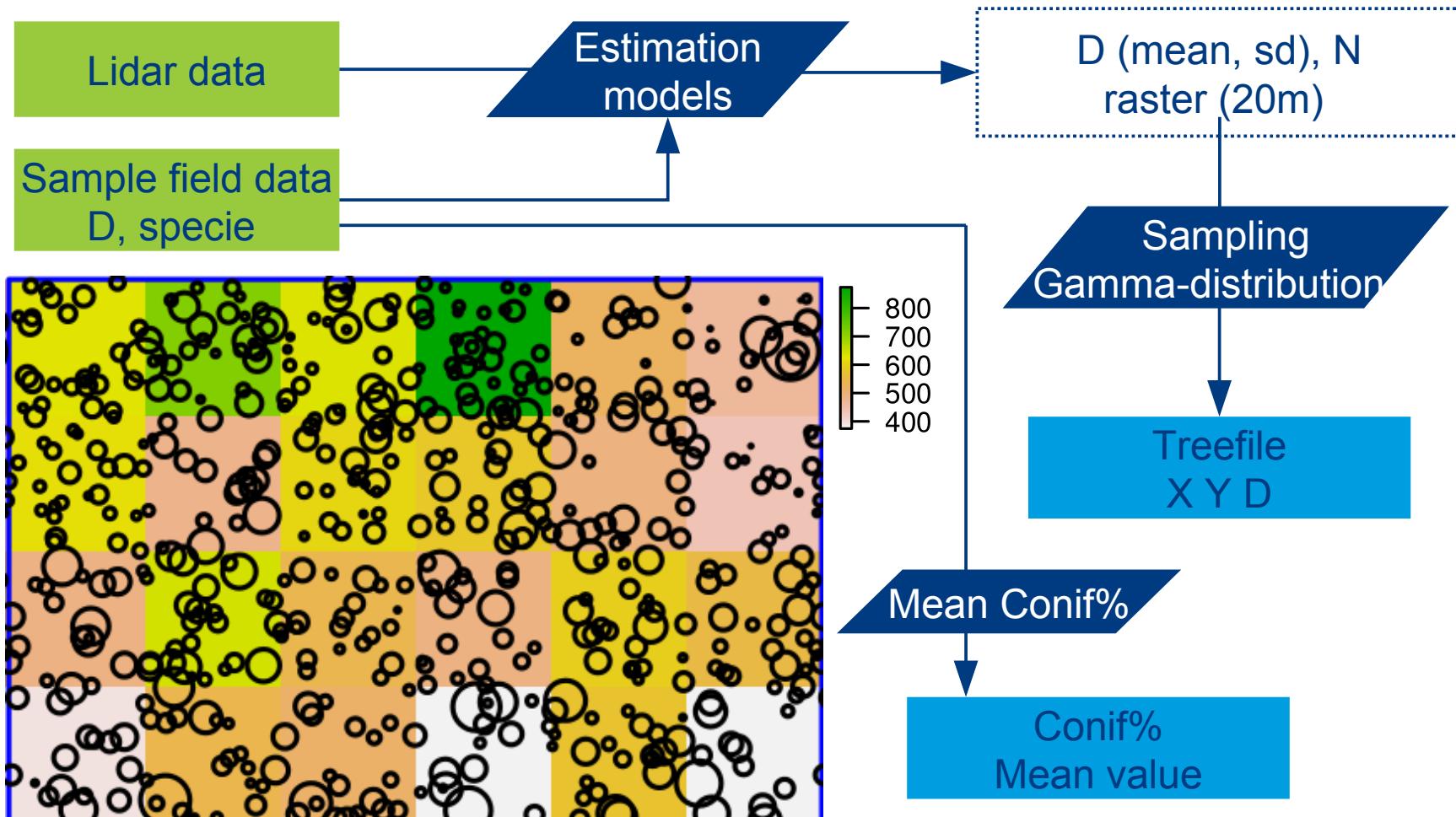
Methods: forest inputs

Lidar tree detection inventory (**LidarTree**)



Methods: forest inputs

Lidar area-based inventory (LidarArea)



Material: forest ground truth

Field inventory

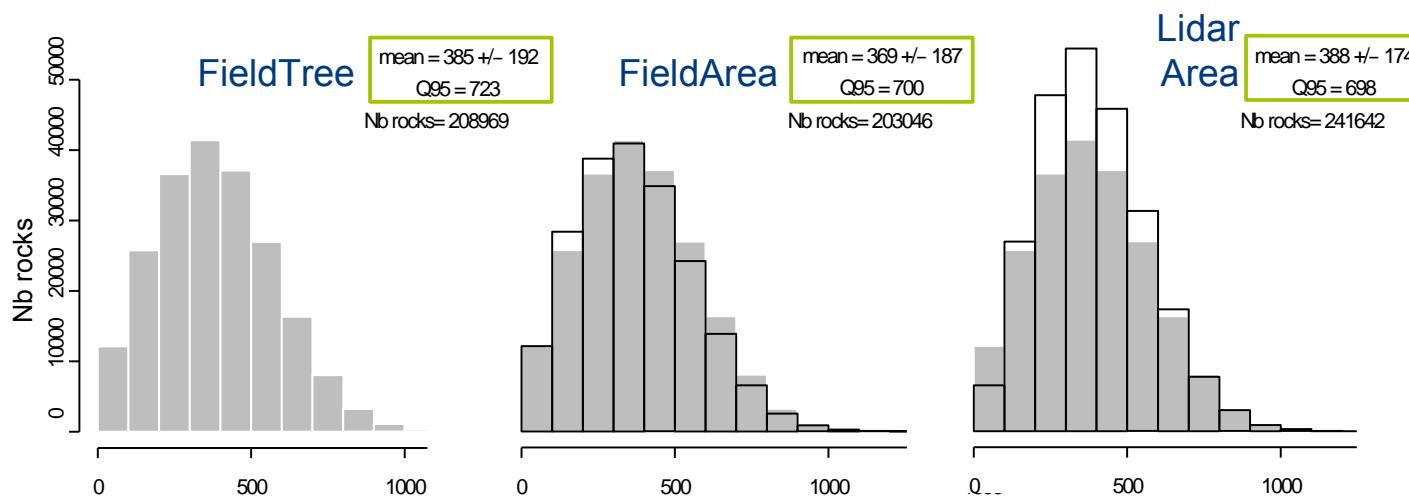
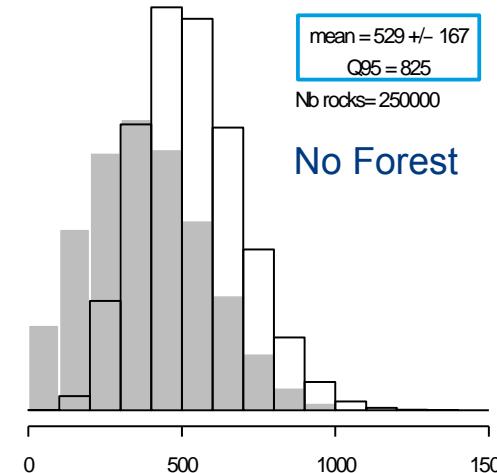
- Position, diameter, specie of all stems above 7.5 cm (DBH)

Site	Saint Agnan	Saint Paul	Valdrôme
Structure	Uneven-aged	Coppice	Even-aged
Species	<i>Abies alba,</i> <i>Fagus Sylvatica</i>	<i>Acer opalus, Corylus avellanaum, Sorbus aria,</i> <i>Quercus pubescens</i>	<i>Pinus nigra</i>
Size (m ²)	80x125	50x50	50x200
Basal area (m ² .ha ⁻¹)	32.5	31.2	45.5
Diameter (cm) (mean ± sd)	30.1±15.7	12.5±8.0	22.3±8.3
Stem density (ha ⁻¹)	359	1800	1026

Results: coppice stand

Distribution of output energies

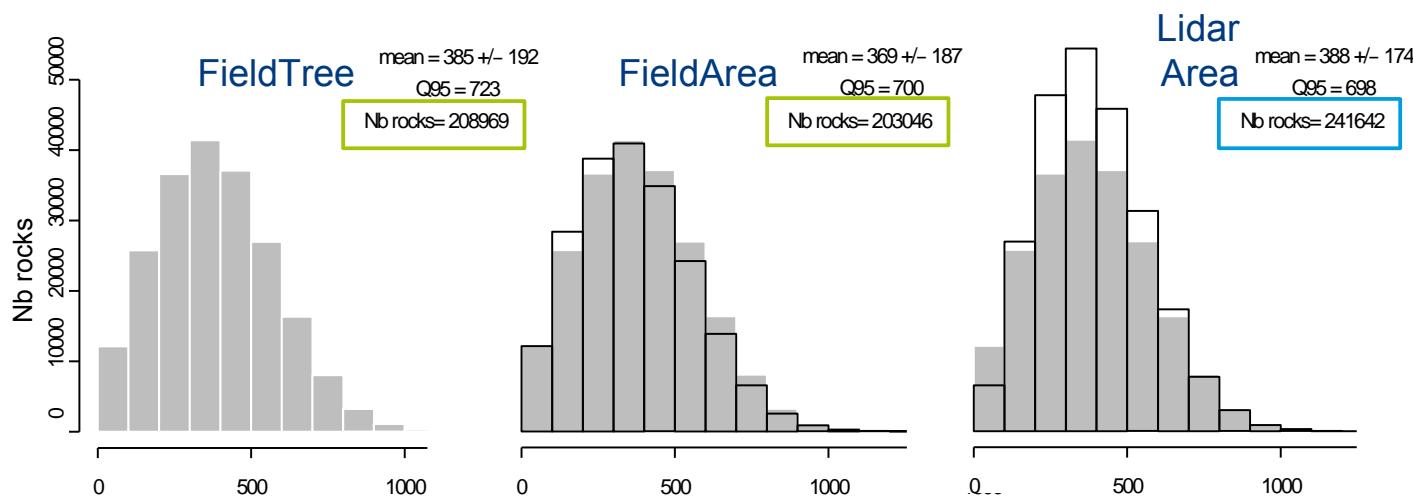
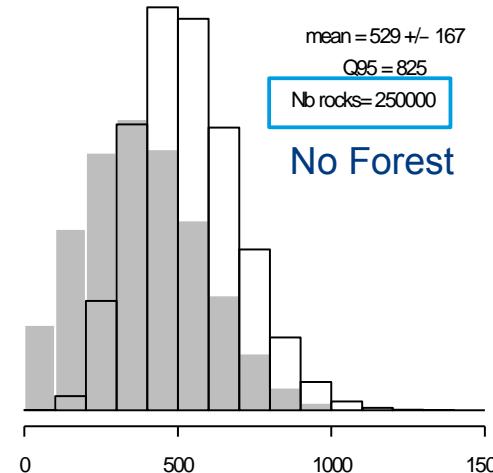
- Energie values similar for all forest input data

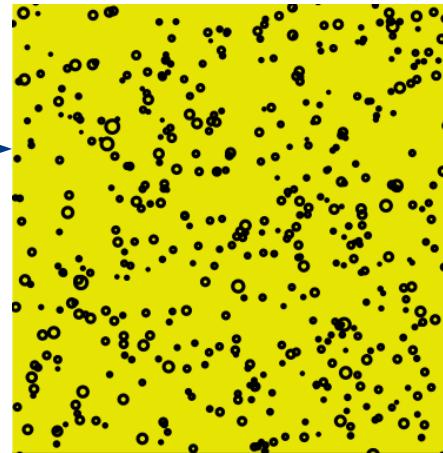
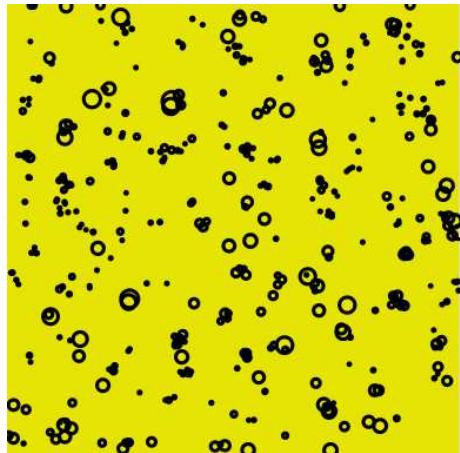


Results: coppice stand

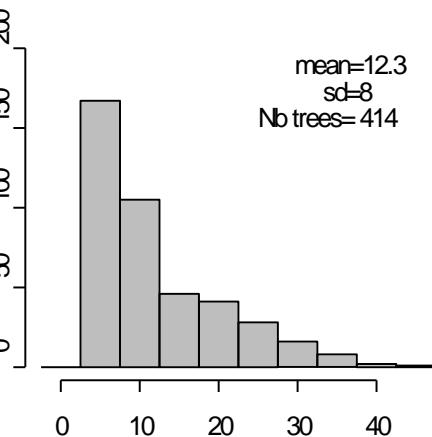
Distribution of output energies

- Energie values similar for all forest input data
- More passing rocks for the LidarArea input

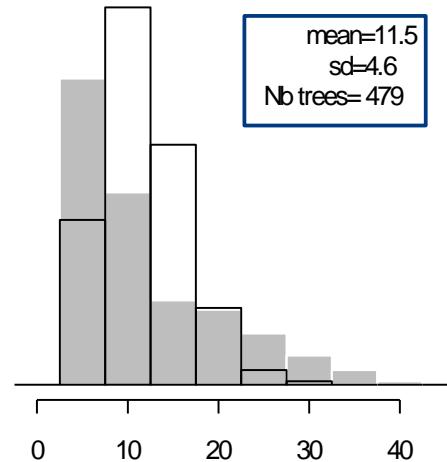




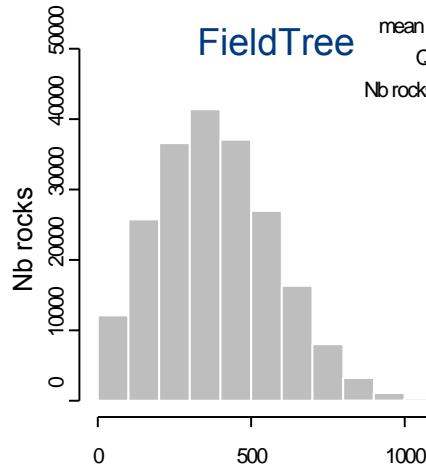
mean=12.3
sd=8
Nb trees= 414



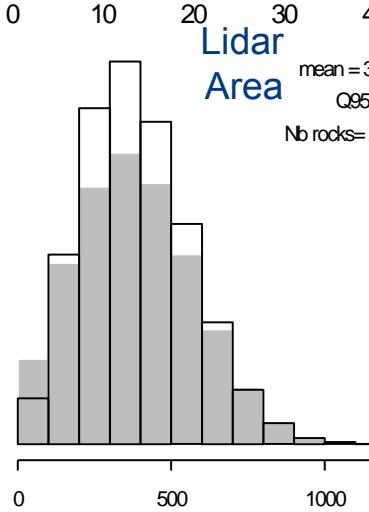
mean=11.5
sd=4.6
Nb trees= 479



FieldTree
mean = 385 +/- 192
Q95 = 723
Nb rocks= 208969



Lidar
Area
mean = 388 +/- 174
Q95 = 698
Nb rocks= 241642



Treefile

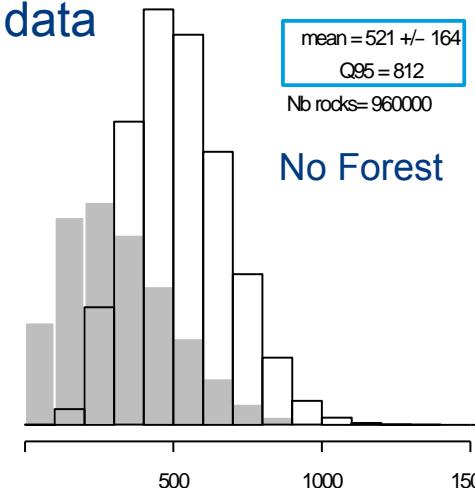
Diameter
distribution

Energy
distribution

Results: coniferous, even-aged stand

Distribution of output energies

- Energie values almost similar for all forest input data



FieldTree

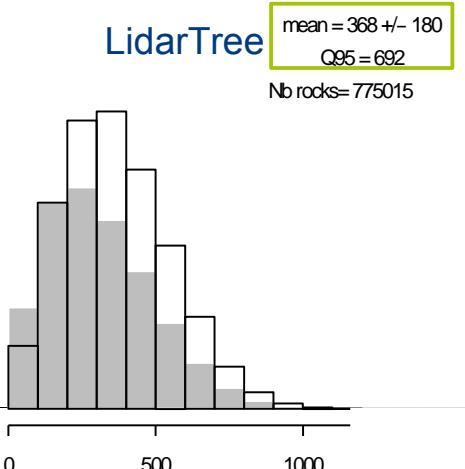
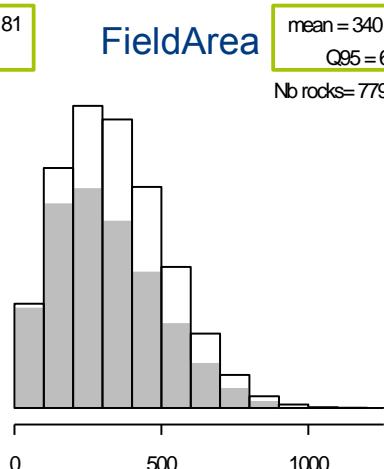
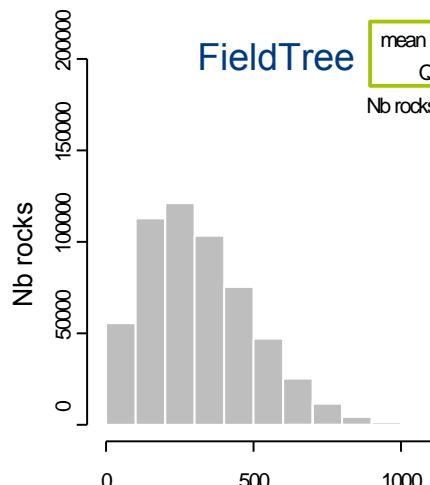
mean = 317 +/- 181
Q95 = 652
Nb rocks = 558549

FieldArea

mean = 340 +/- 179
Q95 = 663
Nb rocks = 779866

LidarTree

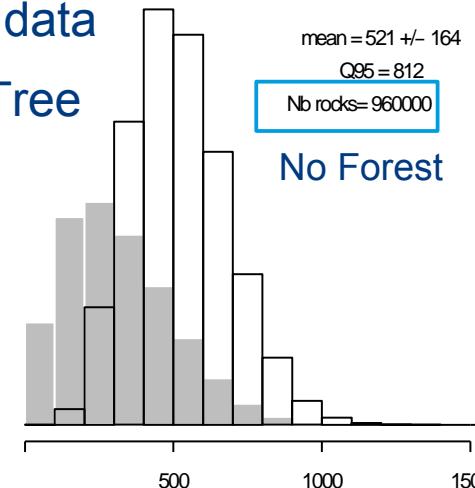
mean = 368 +/- 180
Q95 = 692
Nb rocks = 775015

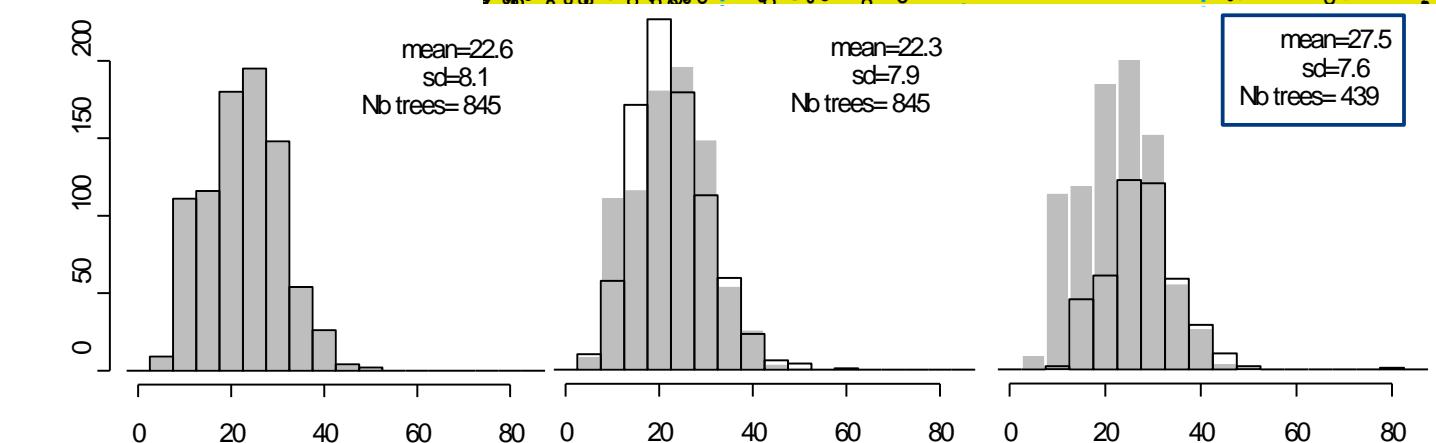
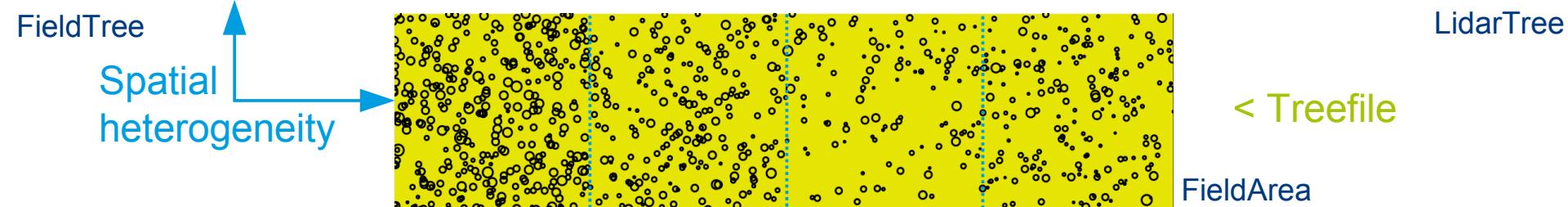
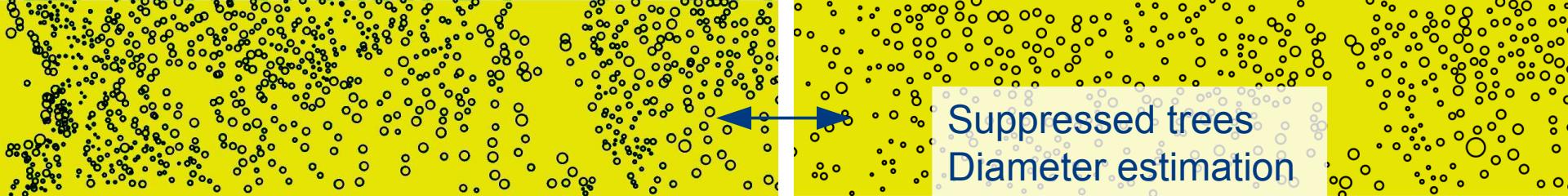


Results: coniferous, even-aged stand

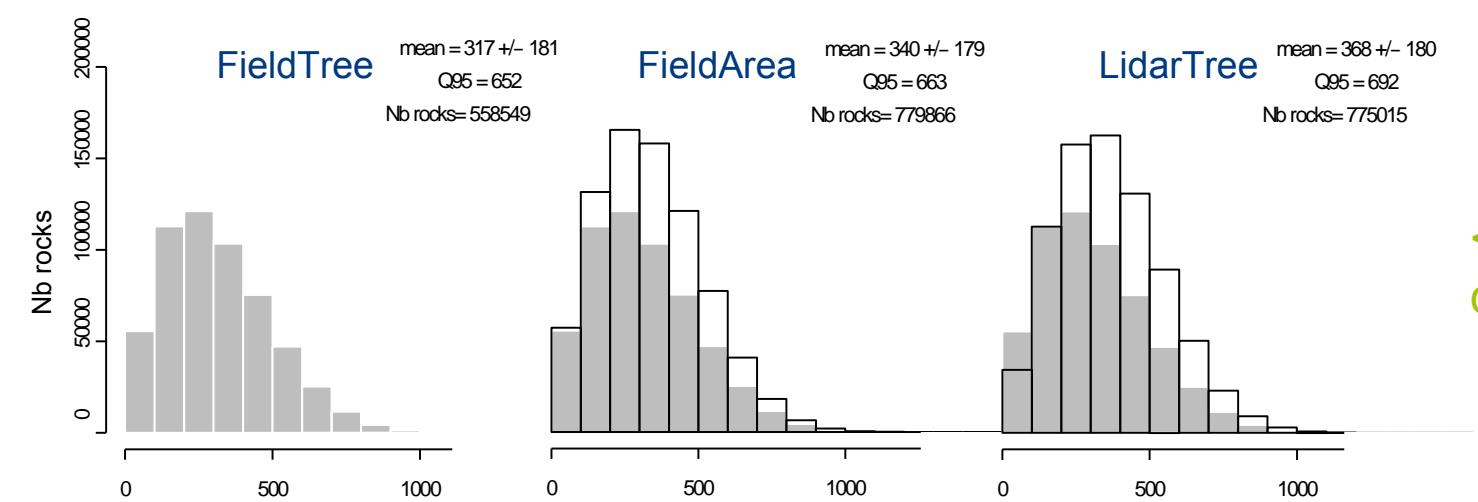
Distribution of output energies

- Energie values almost similar for all forest input data
- More passing rocks for the FieldArea and LidarTree





< Diameter distribution

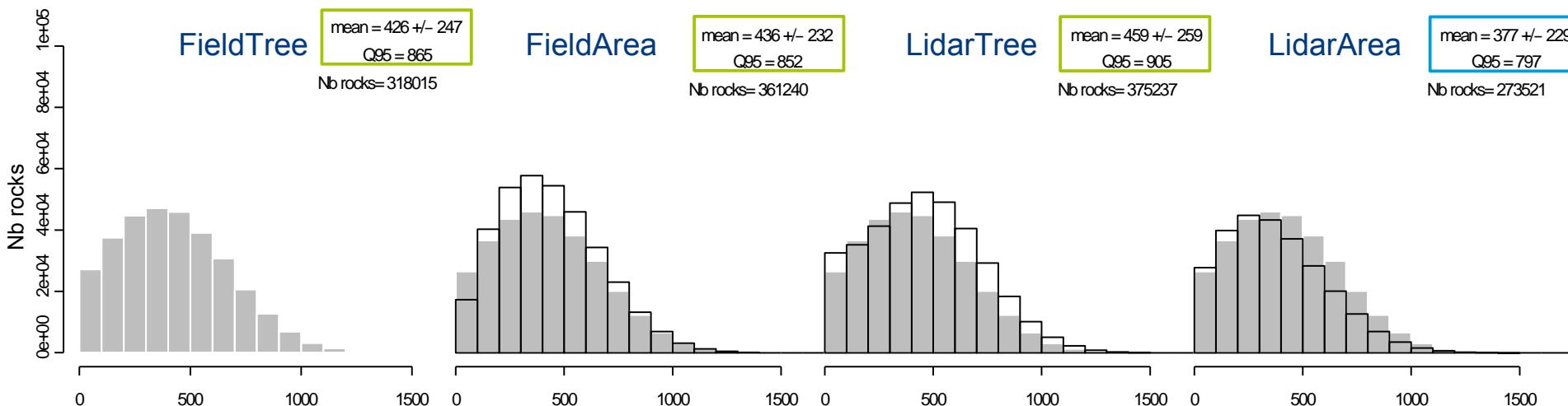
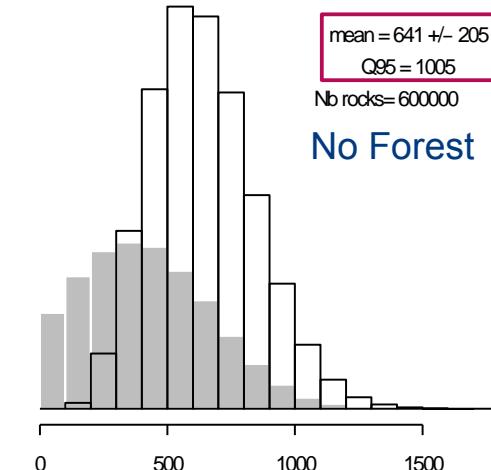


< Energy distribution

Results: uneven-aged, mixed forest

Distribution of output energies

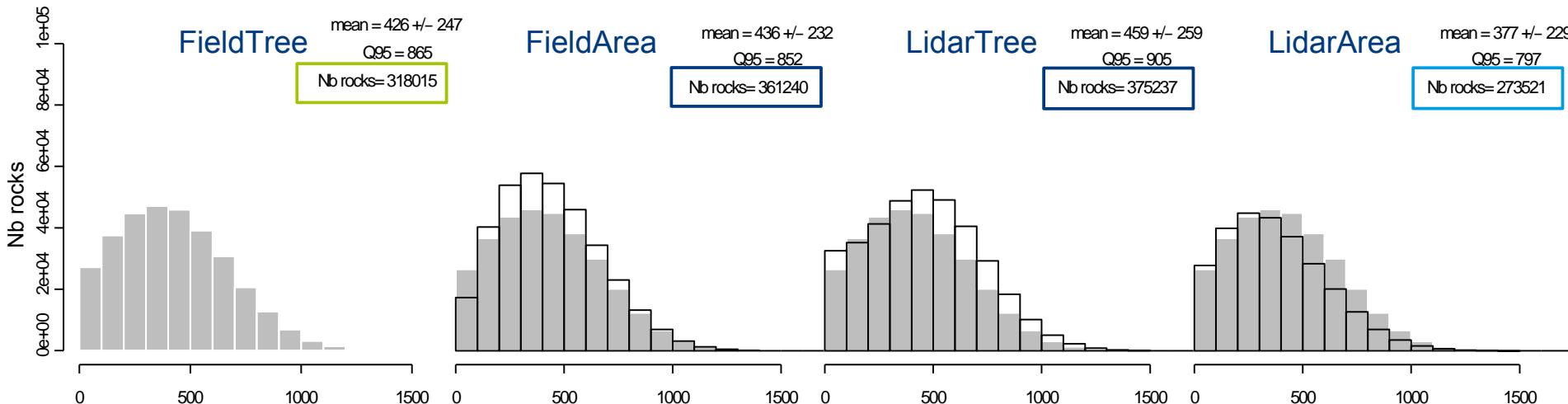
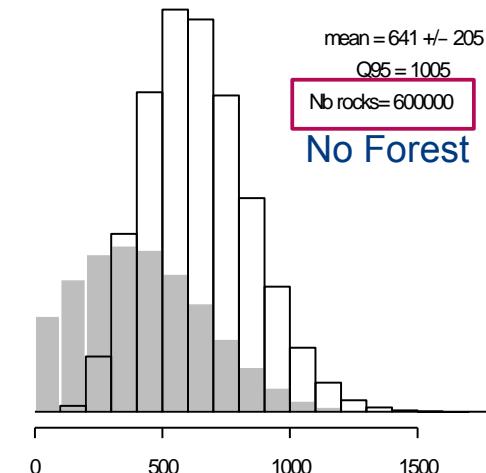
- Energie values almost similar for all forest input data, except LidarArea

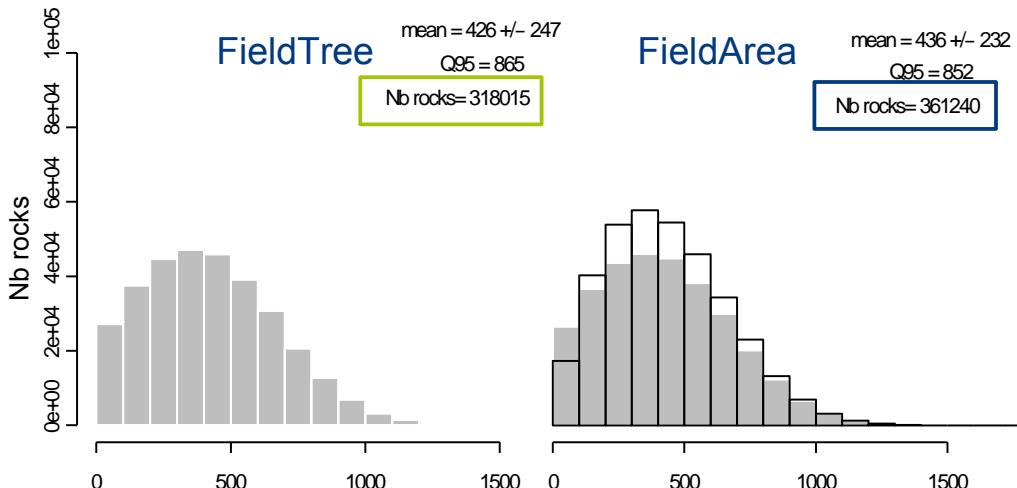
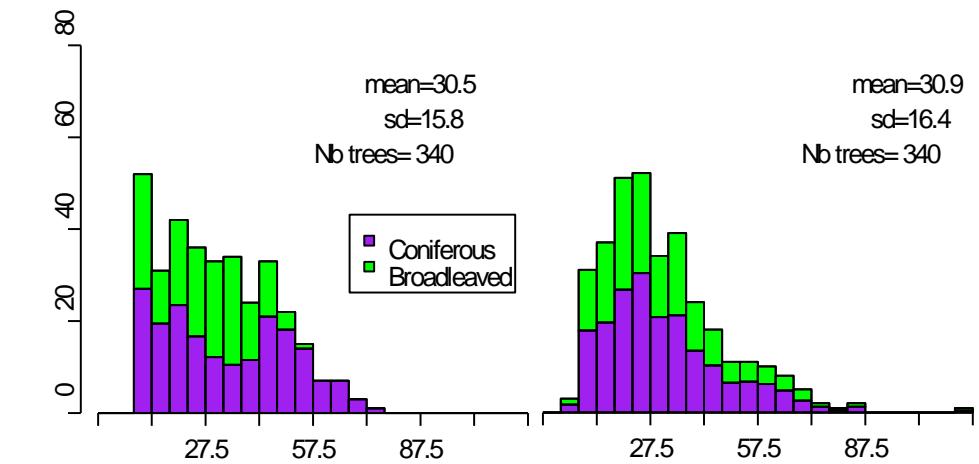
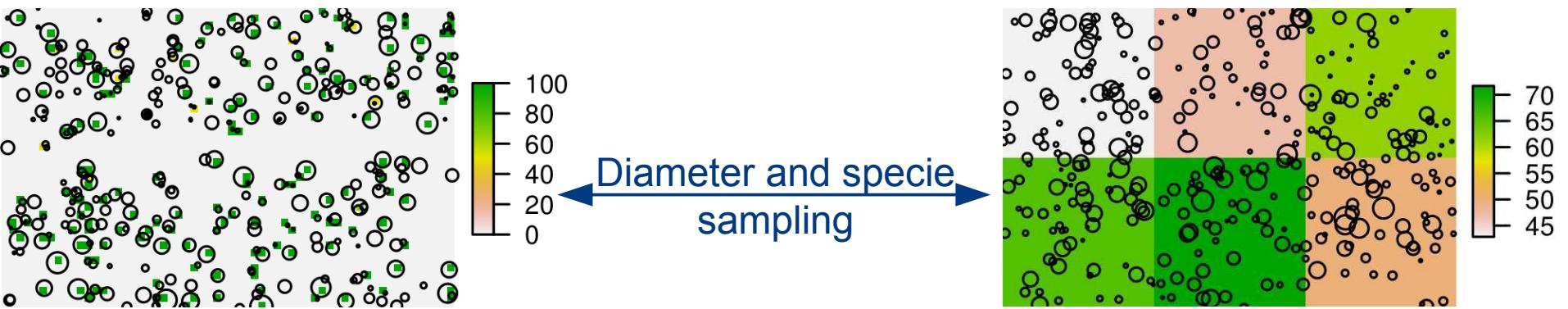


Results: uneven-aged, mixed forest

Distribution of output energies

- Energie values almost similar for all forest input data, except LidarArea
- More passing rocks for the FieldArea and LidarTree, less for the LidarArea





Results: summary (stand level)

Assessment of forest protection effect

- Good results for energy dissipation but poorer for number of passages

Limitations

- RockyFor3D: species sampling (not diameter dependant)
- Model limitations
 - Diameter distribution modelled as gamma distribution
 - Spatial distribution (aggregation) not accounted for
- Input data limitations
 - Field: spatial heterogeneity (wide area sampling)
 - Lidar Tree-level: suppressed trees and diameter estimation
 - Lidar Area-level: potentially important error at « pixel » level
 - Lidar: species ?

Perspectives

RockyFor3D

- Improve species, diameter and aggregation implementation

Wide area assessment

- Effect of field sampling intensity
- Correct lidar tree-level bias
- Smoothing of pixel-level errors for the lidar area-level estimations ?
- Ground truth costly → rely on simulations ?

CONTACT

jean-matthieu.monnet@irstea.fr

UR Mountain Ecosystems

Irstea Grenoble

FRANCE

+33 (0)4 76 76 28 06

