Based on innovative and proprietary Waveform-LiDAR technology, RIEGL laser scanners and systems provide an outstanding high-density point cloud ideally suited for applications in forestry and precision agriculture. Advanced processing algorithms account for a full exploitation of the information included in scan data. Multi-target capability enables excellent vegetation penetration and the computing of detailed terrain models. Point classification is the basis for growth monitoring, height modeling, or the detection of deadfall.
**Forestry Applications**

Data Acquisition using Airborne, UAV-based, and Terrestrial Laser Scanning

**AIRBORNE**

- VQ-580 II at 1064nm wavelength
- VQ-480 II at 1550nm wavelength

- Vegetation mask: green areas of vegetation higher than 3m and larger than 10 sqm
- Canopy model: vegetation colored by height above ground
- Single tree delineation: colors represent the area covered by a single tree
- Crown coverage: terrain colored by the percentage of vegetation coverage

**UAV-BASED**

- Segmented point cloud
- 3D model of trees

- Display of single trees
- Volume model for biomass measurement

**TERRESTRIAL**

- Robust automatic scan data registration even in dense forest

- Point cloud classification of ground & vegetation
- Single tree segmentation
- Tree metrics:
  - DBH (Diameter Breast Height)
  - Tree height
  - Tree length
  - Crown coverage
- Convex hull of crown
- Crown volume

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VEGETATION
Due to the extremely high scanning rates the VUX®-1UAV provides an outstanding high-density point cloud, which makes it ideal for forestry applications.

GROUND CONDITIONS
The excellent vegetation penetration rate results in a high number of ground returns that can be used to generate very detailed terrain models. The sample to the left depicts points classified as ground coloured by reflectance.

GROWTH MONITORING & TREE HEIGHT MODEL
All points classified as vegetation can be coloured by relative height above ground. This results in a relative estimation model of the trees revealing regions of low and high vegetation stands. Growth rates can be documented by comparison of height models collected over a period of time.

SHRUB LAYER & DEADFALL
The undergrowth of a forest consists of shrubby vegetation and seedling trees. It plays an important role in the forest ecosystem and is a habitat for wildlife and birds. The image to the left shows points classified as low vegetation (red) and clearly shows areas of dense natural cover. Furthermore, deadwood can be detected in this data layer.

BARE EARTH
With all vegetation data removed, the remaining points define a very detailed terrain model. This model clearly reveals roads and trenches as well as results of slope instability and erosion.
Crop growth and health is closely monitored in Precision Farming in order to minimize the use of fertilizers or irrigation. Airborne laser scanning data enable to observe plant growth – while at the same time displaying changes in ground surface – or to detect areas of irregularities.

**ADVANTAGES OF LASER SCANNING IN VEGETATION MONITORING**

By contrast to photogrammetry, which is limited to determining Digital Surface Models (DSM), the technique of laser scanning enables the user to capture data suitable for the generation of DSM and Digital Terrain Models (DTM). Advanced processing algorithms account for a full exploitation of the information included in scan data. A typical target situation is measuring areas covered by vegetation. Several target echoes resulting from a single laser pulse emission are obtained by echo digitization and subsequently resolved by online waveform processing, resulting in measurement ranges, echo amplitudes, calibrated target reflectance and pulse shape information.

**CROP GROWTH**

Crop growth and health is closely monitored in Precision Farming in order to minimize the use of fertilizers or irrigation. Airborne laser scanning data enable to observe plant growth – while at the same time displaying changes in ground surface – or to detect areas of irregularities.

**FIELD CHARACTERISTICS**

While plant height cannot per se be interpreted as a direct factor for yield calculation, irregularities due to, e.g., different soil composition, variety of seed type or damage (e.g., weather-related, caused by storm, hail, or rainfall) can easily be discerned and taken as an indicator for further developments and estimation of yield at harvest.

**MONITORING**

Constant monitoring of agricultural areas enables early yield estimation based upon differences in plant growth development.