UNDERSTORY BIOMASS & DRONE
based on SfM data under the canopy

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Introduction

- **What we have known**

Understory vegetation has the important effect on Evapotranspiration.

- **What we don't know about the problem**

It is difficult to get the balance between precision and area scale in understory biomass measurement. Conventional drone methods cannot get information under the canopy.

- **What we did**

Structure from Motion(SfM) was used to reconstruct understory structure in Subcatchment scale more than 10000 m^2 by a manual low-flying drone under the canopy.
The volume of understory vegetation was calculated based on the point cloud data.
Combining with understory biomass data from field harvest to build a regression cubic model between the volume and biomass.

- **What readers expect to find in our study**

The objective is to use the drone to provide detailed three-dimensional data of the understory forest structure with an efficient and economical method.
Revealed the potential of the dense point cloud from drone SfM for estimating understory biomass. Provide an idea of estimating ET from biomass.

Methods

- **Study area**

Composed one subcatchment and three harvest plots, located on Mt. Karasawa near Sano City (Tochigi Prefecture) in central Japan.

Subcatchment K32 (1.1ha) is located in the southwest of Catchment Mt.Karasawa. The plantation forest is made by Japanese cedar and Japanese cypress and was planted in 1972. These trees have a mean diameter at breast height (DBH) of 19.1 ± 3.9 cm, a mean stand height of 16.0 m. The original stand density was 2198 stems/ha.(Fig.1)

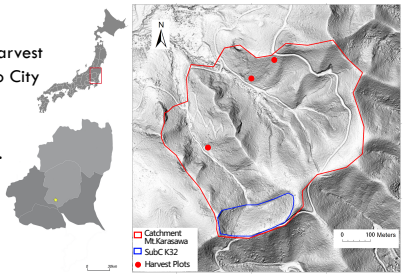


Figure 1-Study areas with the differents scale zones

Three Harvest plots are located outside of K32 and surrounded with ropes in 4*4m grid. A total of 48 sample areas.(Fig.2)

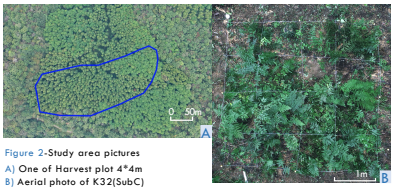


Figure 2-Study area pictures
A) One of Harvest plot 4*4m
B) Aerial photo of K32(SubC)

- **Drone - Structure from Motion(SfM)**

Low-cost Unmanned Aerial Vehicle DJI Mavic 2 Pro drone (Fig.3) was used for photogrammetry survey of the understory. The drone flies under the tree canopy by manual control with the radial paths to take high overlap photos for K32 and three Harvest plots. The camera was set to trigger automatically in 2 second at the flying height of 5-10m.

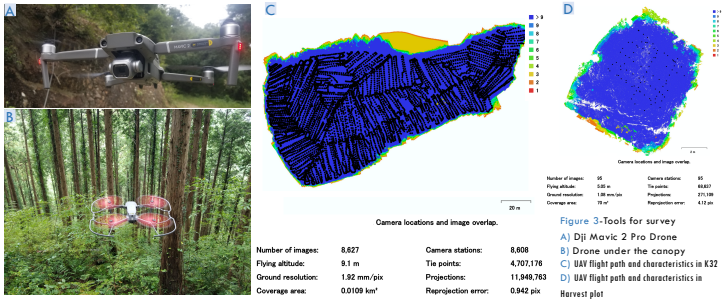


Figure 3-Tools for survey
A) Dji Mavic 2 Pro Drone
B) Drone under the canopy
C) UAV flight path and characteristics in K32
D) UAV flight path and characteristics in Harvest plot

- **Biomass sampling**

The selected 1 m^2 sampling areas were used at every sampling in three harvest plots(a total of 48 samples). The sample was weighted in the field (fresh biomass, FB). Understory vegetation will be harvested after being measured using drone SfM.

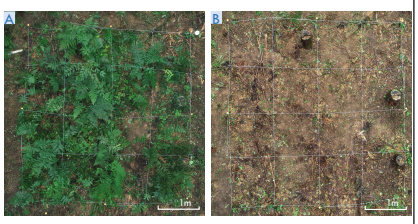


Figure 4-Harvest plot 1
A) Pre-Harvest plot 1 B) Post-Harvest plot 1

- **Processing**

Photogrammetry data were precessed in Agisoft Mateshape software.
The projected volume of understory was calculated by the Canopy Height Model(CHM) generated from point cloud data.
The relationship between projected volume and biomass was modelled using 48 samples from three harvest plots.

Results

- **Point cloud data**

SubC K32 and Harvest plots have the point cloud density of $1.1*10^5/m^2$ and $3*10^5/m^2$ respectively

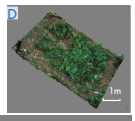
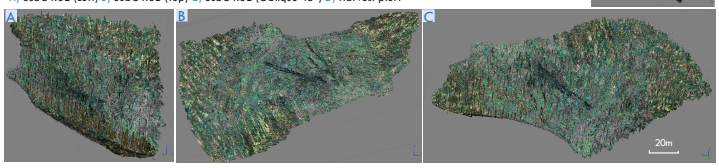


Figure 5-Point cloud data
A) SubC K32 (Left) B) SubC K32 (Top) C) SubC K32 (Oblique 45°) D) Harvest plot1



- **Canopy Height Model**

Point clouds were classified into ground points and vegetation points by Cloth Simulation Filter(CSF). Ground Z value were subtracted from vegetation point cloud data based on X,Y coordinates to get relative height of the understory vegetation—Canopy Height Model(CHM). Remove the tree trunk from the cloud by assigning Null value to greater than the threshold(2m) value. Point cloud data was projected as raster data with a resolution of 5*5cm.

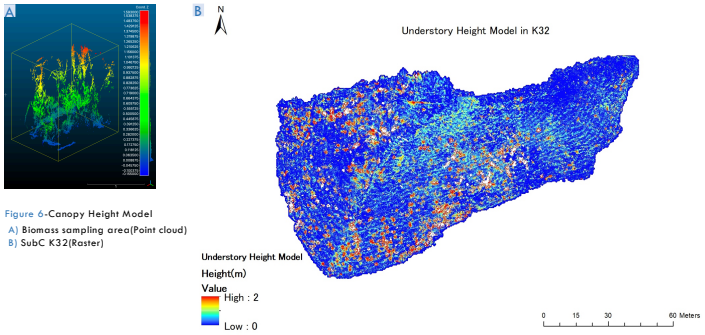


Figure 6-Canopy Height Model
A) Biomass sampling area(Point cloud)
B) SubC K32(Raster)

- **Biomass Model**

A regression cubic model based on the CHM has acceptable accuracy and biomass estimate capability ($P<0.01$), with a coefficient of determination of 0.749.

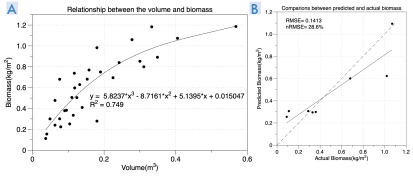


Figure 7-Biomass Model
A) Relationship between the volume and biomass(FB)
B) Relationship between the actual and predicted biomass

- **Outcomes**

Spatial distribution map of understory biomass in the study area with 0.5m resolution, mapped with Biomass Model and CHM in K32.

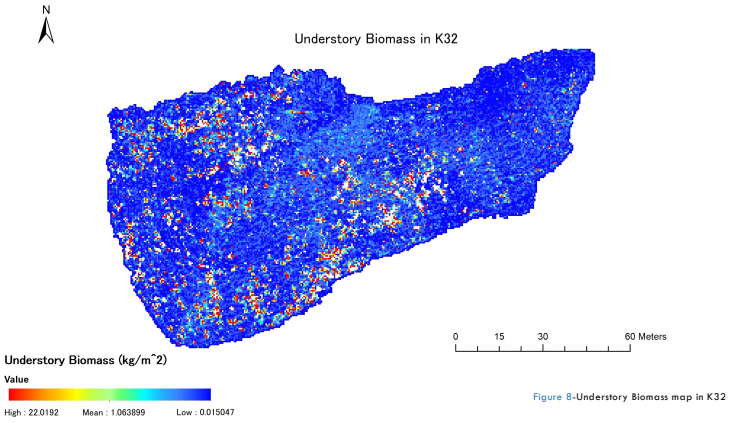


Figure 8-Understory Biomass map in K32

Discussion

- Compared to other drone methods using above canopy data, our under the canopy flight method obtained understory information and mapped biomass distribution in the Subcatchemnt scale.
- Low-flying drone under the canopy reveals the potential for SfM data to measure understory vegetation biomass, but manual control is inefficient and the development of automated flight systems is promising.

References

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