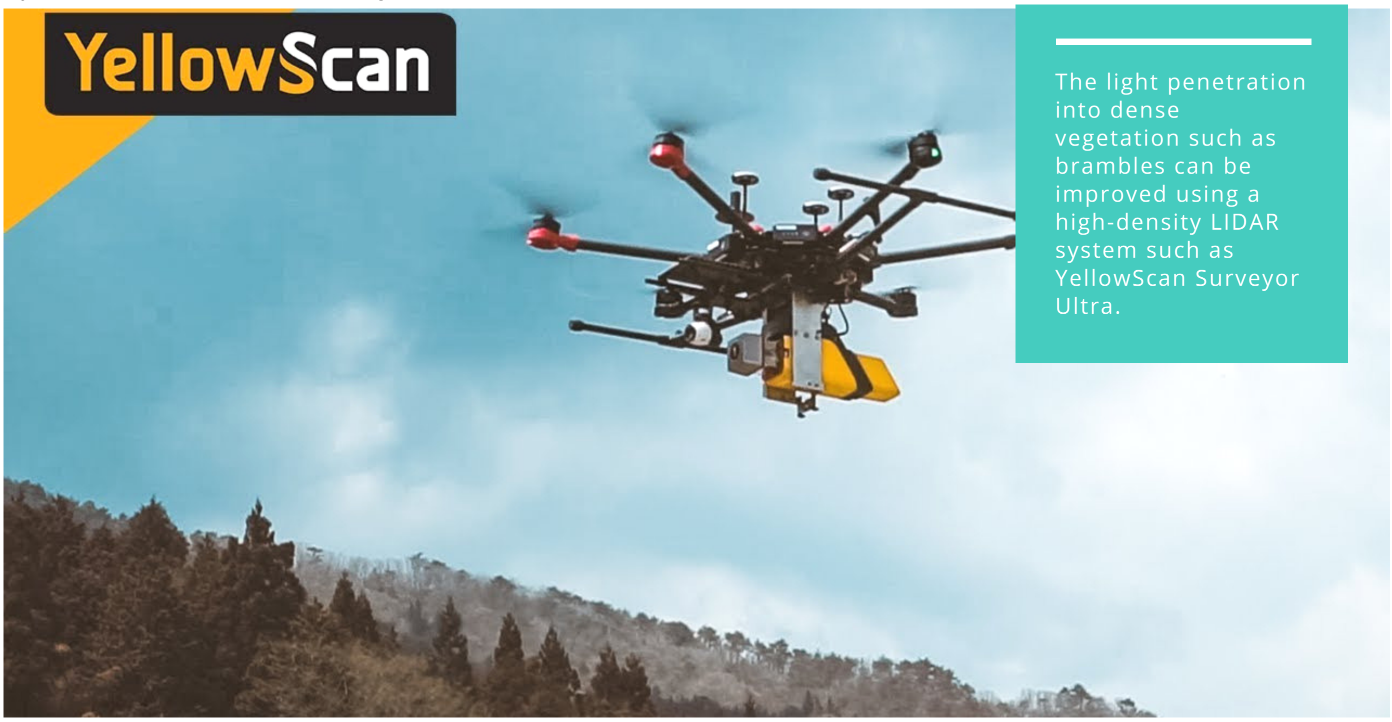
UAV LiDAR FOR ECOLOGICAL RESTORATION OF WETLANDS

New technologies such as airborne or UAV LiDAR seem to be interesting alternative tools for survey of wetlands topography and hydrology.

by Marie de Boisvilliers and Morgane Selve



The light penetration into dense vegetation such as brambles can be improved using a high-density LIDAR system such as YellowScan Surveyor Ultra.

Wetlands are essential ecosystems which provide heaps of benefits to human societies. Their functionality strongly depends on hydrology and topography of the watershed. However using terrestrial topographical surveys methods may be a challenging task in wetlands. Flooded areas, muddy terrain and low vegetation may slow substantially the movement of the surveyors, while the high vegetation may decrease the reception of GPS receivers. New technologies such as airborne or UAV LiDAR seem to be interesting alternative tools for survey of wetlands topography and hydrology.

Importance of Wetlands and Their Hydrology

Wetlands are ecosystems where water meets land. They are often undervalued and have become globally threatened: since 1900, two thirds of natural wetlands have been destroyed. Their decline and fragmentation can cause the loss of their essential ecological functions, and consequently the loss of all the benefits they provide.

Besides conserving the remaining wetlands, there is a need to help wetlands recover from degradation or fragmentation. Many projects of

About Author

Marie de Boisvilliers

Environmental Engineer and Project Manager
L'Avion Jaune
Montferrier-sur-Lez, France
Email: *info@lavionjaune.fr*

Morgane Selve

Communication manager
YellowScan
Montferrier-sur-Lez, France
Email: *morgane.selve@yellowscan-lidar.com*

ecological restoration of wetlands have been undertaken in the past decades and lessons have been learnt. In many cases, degraded wetlands have problems that originated with alteration of channel form or physical characteristics, which in turn have led to habitat degradation and loss of biodiversity. Therefore a key principle for successful wetlands restoration is the understanding of the physical terrain structure and natural hydrology.

The Case Study of Mou de Pleure

The bog of Mou de Pleure, located in France, in Franche Comté region, is a case study of wetlands degradation. Since the end of the 19th century, this bog has suffered a wide range of damages. One of the most important was the digging of a ditch in the 1980s for drainage of cultivated lands. This hydrological alteration has led to various negative impacts such as decrease of water storage capacity (which normally contributes in flooding prevention), afforestation and loss of rare local species observed in the past.

The Mou de Pleure is one of the rare peatlands in the region which is located in the plains, and according to ancient studies, it used to be the widest and the most flourishing of all the swamps in the plain of Bresse. Therefore a restoration project has been initiated by the Regional Conservatory for Natural Areas (CEN Franche Comté).

Interests of UAV LiDAR

The restoration project required an accurate digital terrain model (DTM) on the bog and its watershed for studying the hydromorphology. The team of L'Avion Jaune, a French aerial mapping operator based in Montpellier, decided to use a LiDAR scanner on a multirotor platform to conduct the survey.

The study area was around 50 hectares. In the center, the bog takes the form of a dense wooded area of 900 m long by 200 m wide, along the Mou stream. Outside this forested area, the Mou de Pleure is covered by meadows and cultures. The use of unmanned aerial vehicles (UAV), especially multirotor, is typically well-suited for an area of these dimensions. It is too extended to be surveyed cost-effectively by terrestrial techniques, and too small to undertake aerial surveys. Besides, the terrain access for terrestrial surveyors is complicated by the muddy environment and the dense vegetation.

Another stake of this survey was the vegetation cover, as the degradation of the bog has led to a dense afforestation of the riversides. The use of LiDAR scanner is especially relevant in this case, comparing for example to photogrammetry, as the emitted laser pulse can reach through the spaces in the canopy and provide measurement points the terrain.

L'Avion Jaune team chose to operate with the YellowScan Surveyor. The system is an ultra-lightweight standalone mapping system, selfpowered which integrates easily to multiple platform types. With a weight of 1.6kg, it is one of the lightest fully integrated laser scanning systems in the world. The Surveyor includes an onboard computer which manages the three main components: a Velodyne laser scanner, a GNSS and an INS, both from Applanix (APX15). The laser scanner has a 300 kHz frequency, making it optimal for mapping through the vegetation cover. Besides the GNSS-inertial solution provides an accuracy of 5 cm, which fulfils the study requirements.

Figure 1: YellowScan LiDAR Scanner.

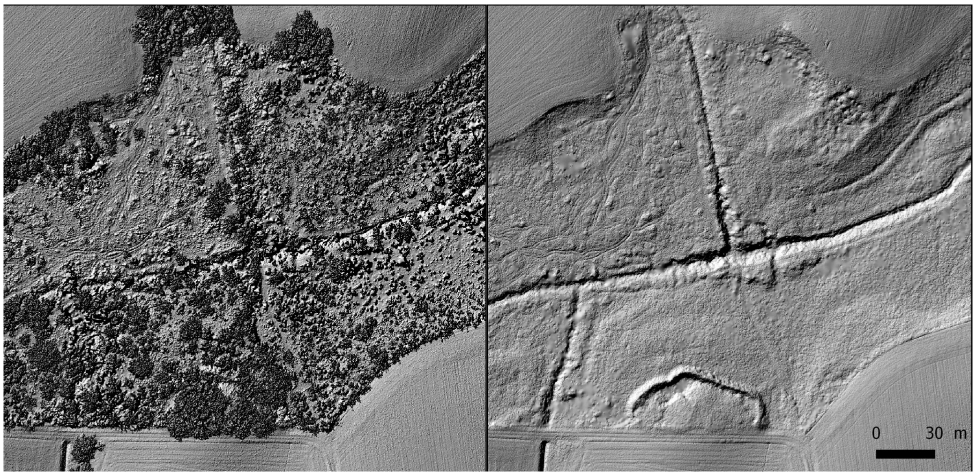


Figure 2: Point Cloud Data (Left) and Digital Elevation Model (Right).

Simple Workflow For Optimal Results

The YellowScan Surveyor system is quick and simple to operate. The fieldwork was completed in one day, including six flights, quality check of the data and picking up of control points. Flights were performed with 5m/s velocity at a 50 m altitude, with a 60 % LiDAR flight line overlap. Four transversal flightlines were added along the wooded area to maximize the point density on the bog.
Back to the office, L'Avion Jaune team ran Post Processed Kinematic (PPK) to the trajectory and generated a georeferenced points cloud with the corrected trajectory. Then, several LiDAR processes were achieved to generate the deliverables, which include noise filtering, flight line matching and classification of the ground. Finally, the point cloud was filtered to keep only ground points, and a DTM was extracted.

The produced point cloud from LiDAR had an average density of 118 pts/m2 over the whole area. Point density reached up to 280 pts/m2 in some areas with crossed overlap. Flooded areas presented a lower point density as infrared light (wavelength : 905 nm) are easily absorbed by water. However the average point density over the bog was satisfactory with 70 pts/m2.
The average density of ground points was of 96 pts/m2 over the whole study area. Under vegetation cover, ground point density ranges from 5 to 25 pts/m2. In some specific cases, the low vegetation consisting of brambles was so dense that the LiDAR beam could not reach the soil, so that some blank areas, fortunately of limited extent, remains in the dataset.

Further processing was completed by a specialised environmental consulting company to analyse hydrology. Contours lines were extracted, and watershed algorithm was applied to map the rivers and the streams. Vertical cross section of the point cloud helped identify the key hydrological elements. The DTM was used to build an hydraulic model and make some flow simulation. Finally, three restoration scenarios have been proposed to restore the Mou de Pleure bog.

Perspectives

Wetlands occur in every country, and under every climate. Environmental studies and restoration actions are undertaken worldwide. UAV LiDAR appears to be an effective tool to characterise hydrology and could be used in other type of wetlands all over the world.

Dealing with flooded areas may limit the point density in some wetlands as water absorbed infrared wavelength. It can be useful to adapt the flight planning to maximize point density, by increasing overlap and/or reducing flight height or speed. A topo-bathymetric LiDAR may also be an interesting tool to overcome this issue.

The light penetration into dense vegetation such as brambles might be improved using a high-density LiDAR system such as YellowScan Surveyor Ultra which includes a laser scanner with a frequency of 600 khz.

This survey was completed with a multirotor UAV which is well-suited for small areas. However a vertical takeoff and landing UAV with a YellowScan Surveyor Ultra could be helpful to survey cost-effectively more extended wetlands areas. This is a well-suited solution for larger areas as you can fly more than 90 minutes and map 700 hectares. As well, the vertical takeoff is a real asset when you need to fly from area that are difficult to access.

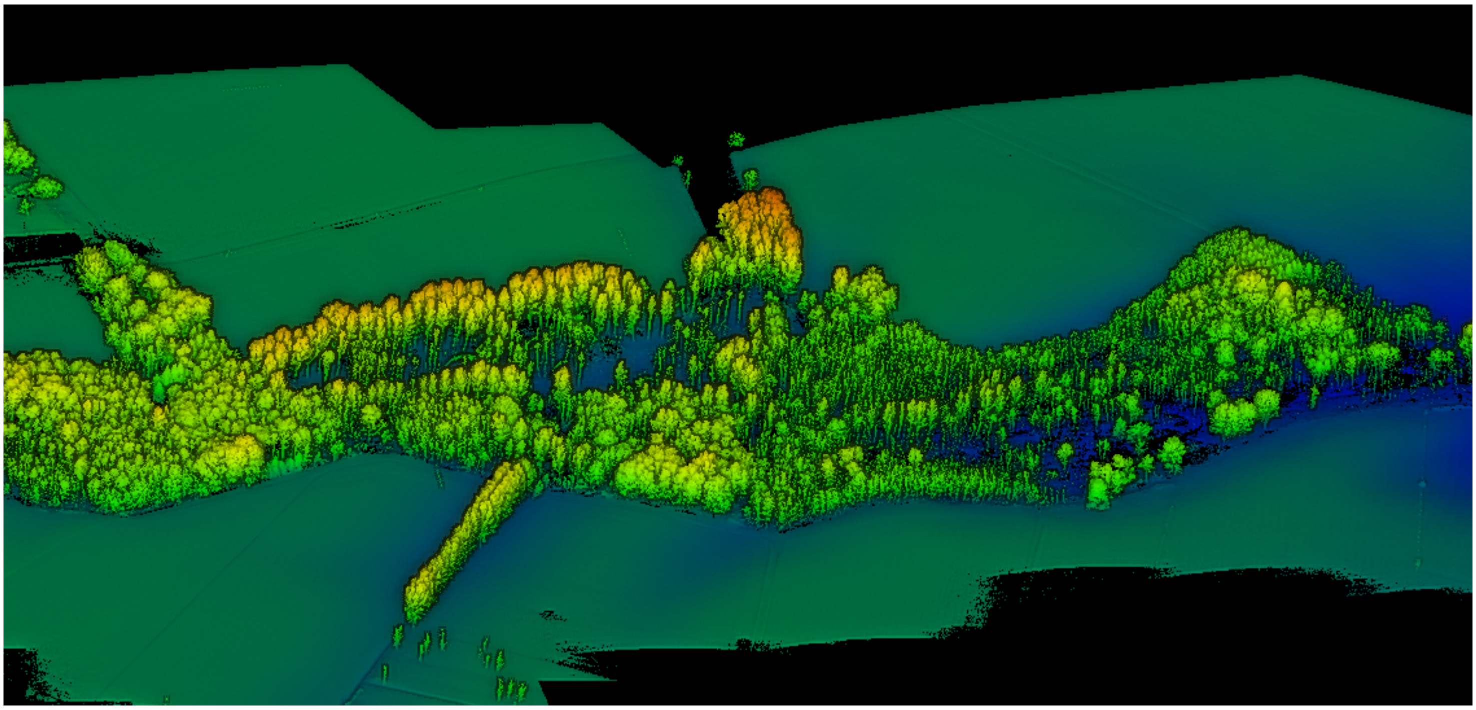


Figure 3: Wetland Restoration Point Cloud.