

P r o j e c t I n f o r m a t i o n

Title: Creating vegetation map using UAV at seaside 'Palouki' forest (Greece)

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P r o j e c t d e s c r i p t i o n

As it is well known the last years Greece is trying to develop it 's own resources such as buildings, airports, ports, forests and places with amazing natural beauty. This project is about a proposition of a group of volunteers to the local municipality of Ilida, a place near Ancient Olympia, in order to protect, reserve and develop a small forest of pines by the sea. The area is named "Palouki" and has great historic importance for the local population. It was the place where the Germans during the second world war expected the landing of the allies but the landing ,as we all know ,took place in Normandy. So beyond the sand there are many cabinets of German artillery made by stone. Our purpose is to highlight to the local authorities a project which they can implement with a small amount of money and improve the image of the forest by creating a recreation park by the sea. The cartographic background of the area was very poor so i decided to explore my capacities in Photogrammetry using UAV.



Pic 1 : South view of Palouki forest near Ancient Olympia

In collaboration with my colleague Stelios Xatzakos (Civil Engineer from Sparta, owner of the UAV) and the advices of my friend and teacher Yiannis Yianniris ,we planned a flight which I would be able to elaborate with Photomod Lite. So we make sure during the programming of the flight that the area of interest should covered by up to 40 images.

I n p u t d a t a

Collected Data (Specs of UAV & Camera)

Receiving data from the air has conducted using a drone UAV type wing (SenseFly Swinglet Cam). The usage of the UAV ensured the need for high resolution and high accuracy. The operating principle of the method is based on the combination of the aircraft and a digital

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camera. The machine is Built in the fuselage of the aircraft and with the help of a digital camera, it ensures the reception of a sufficient number of photographs to cover the whole of the region of interest. The pictures are taken in accordance with premeditated flight plan which contained the exact path of the aircraft and the points which will be held in every camera shot. All these are "loaded" on autopilot of the aircraft in the form of geographic code that uses the State reference system GGRS87.

SPECIFICATIONS OF THE UAV

Wingspan: 80cm
Weight (typ.): 500gr
Battery: Lithium - Polymer
Duration: 30 minutes flight
Maximum Range: Up to 20km
Push System: Electric propeller
Speed Flight: 30 - 50 Km / h
Digital camera: 12 MP
Communication Link: 2.4GHz radio modem
Navigation: Up to 20 points (waypoints)



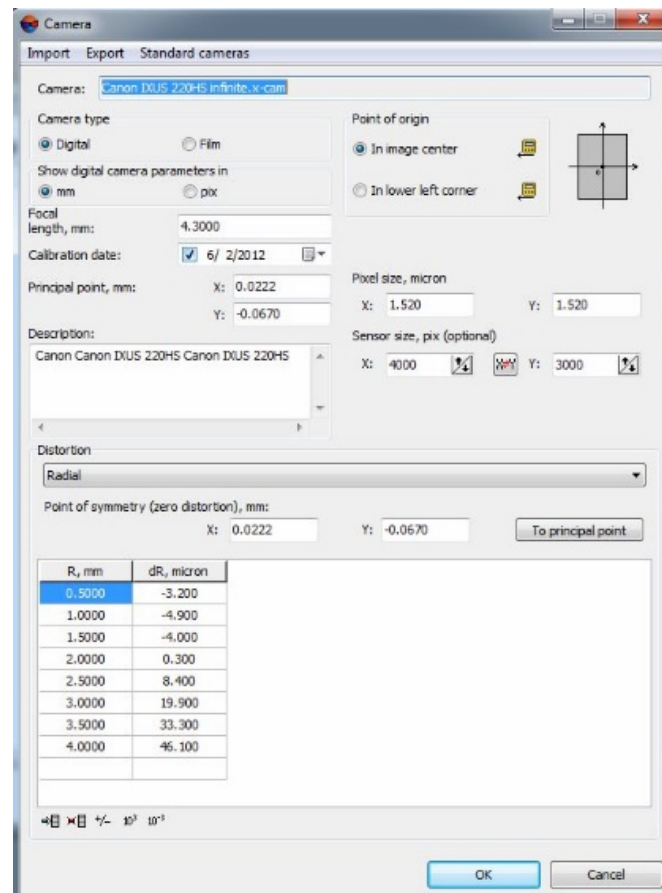
The digital camera used for the project was IXUS 220 HS (company CANON). The camera features a CMOS sensor technology CCD (charged couple device sensor) and can provide image resolution **12.1 megapixel**, while the size of each pixel is **1.52 micrometers**. When taking the photographs used a wide angle lens with an initial focal length $f = 4.3\text{mm}$. The dimensions of the image **4000 * 3000 pixel**.



The camera comes already calibrated and fully electronic integrated by the manufacturer (Sensefly). Below I give you the camera parameters during the procedure of the interior orientation.

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Pic 2 : Camera parameters – Interior orientation

Camera Technical Details

IMAGE SENSOR

Type – 1/2.3 type back-illuminated CMOS

Effective Pixels – Approx. 12.1M

Color Filter Type – Primary Color

IMAGE PROCESSOR

Type – DIGIC 4 with iSAPS technology

LENS

Focal Length – 4.3 – 21.5 mm (35 mm equivalent: 24 – 120 mm)

Zoom – Optical 5x. Digital Approx. 4x (with Digital Tele-Converter Approx. 1.5x or 2.0x and Safety Zoom [1]). Combined Approx. 20x

Maximum f/number – f/2.7 – f/5.9

Construction – 6 elements in 5 groups (3 double sided aspherical lenses (including 1 UA lens), and 1 single sided aspherical lens (including 1 UA lens))

Image Stabilisation – Yes (lens shift-type), Approx. 4-stop. Dynamic IS (in Movie)

Below is one of the collected images 4000X3000 pixels



Pic 3 : One of the images taken by the UAV at 150m height

CONSTRUCTION AND MEASURING CONTROL POINTS

The area of interest is mostly woody (covers the whole forest) and has many parts of sea coverage. For this reason there are no suitable stable constructions or physical marks to use as control points. Therefore it was inevitable to create manmade control points suitable for a flight height of **150m**. According to the initial programming the pixel size on the ground should be about 0.04 X 0.04 m and the size of control points should give an acceptable correlation (**at least 85%**).

Below is a constructed control point (made of soft wood and the color is either black or white depending on the physical background in order to accomplish the best contrast). The area of interest was covered by **5** such control points (4 of them black and the other white). The measurement of the GCP's took place using **GPS STONEX S9 GNSS**

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Pic 4 : Measuring control points (GCP) on the ground

RESULTS OF GCP MEASUREMENT (COORDINATE SYSTEM GGRS87/GREEK GRID)

NAME	EASTING	NORTHING	ELEVATION	TYPE
F001	262427.494	4181488.073	2.358	CONTROL POINT
F002	262346.123	4181396.265	1.672	CONTROL POINT
F003	262269.552	4181174.293	2.046	CONTROL POINT
F004	262492.289	4181138.034	4.749	CONTROL POINT
F005	262557.002	4181320.241	6.731	CONTROL POINT

FLIGHT PLANNING

The UAV has executed the flight in **8 strips** and has collected **52 images**. The flight was designed with **9 waypoints (closed loop)** so the point of takeoff was the same as the point of landing. Below is the log file of the UAV's auto pilot.

```
11:49:29 : Console log file successfully opened
11:49:29 : === New session : Tuesday 24 July 11:49:29 2012 ===
11:49:29 : Robot created swinglef_cam_0
11:49:30 : En route to waypoint 0
11:49:30 : Idle (running preflight checks)
11:49:44 : Idle (ready to take off)
11:50:25 : Log file swinglef_cam_0_0.log successfully opened.
11:50:25 : Taking off
11:50:57 : En route to home waypoint
11:51:51 : En route to waypoint 0
```

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11:52:18 : En route to waypoint 1
11:52:37 : En route to waypoint 2
11:52:39 : Taking photo #1
11:52:43 : En route to waypoint 2
11:52:50 : Taking photo #2
11:52:54 : En route to waypoint 2
11:53:01 : Taking photo #3
11:53:05 : En route to waypoint 2
11:53:11 : Taking photo #4
.....
12:01:16 : Taking photo #51
12:01:20 : En route to waypoint 9
12:01:21 : Taking photo #52
12:01:26 : En route to waypoint 9
12:01:31 : En route to waypoint 0
12:02:18 : En route to waypoint 1
12:02:30 : En route to home waypoint
12:02:51 : Landing on home waypoint
12:03:45 : Log file closed.

H A R D W A R E P R O F I L E

COMPONENT	DESCRIPTION
PC	PENTIUM I3
RAM	16 GB
HD	250 GB
GRAPHICS CARD	NVIDIA QUADRO 600
3D GLASSES	NVIDIA 3D VISION
3D MONITOR	SAMSUNG SYNCMASTER 2233

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PROJECT WORKFLOW DESCRIPTION

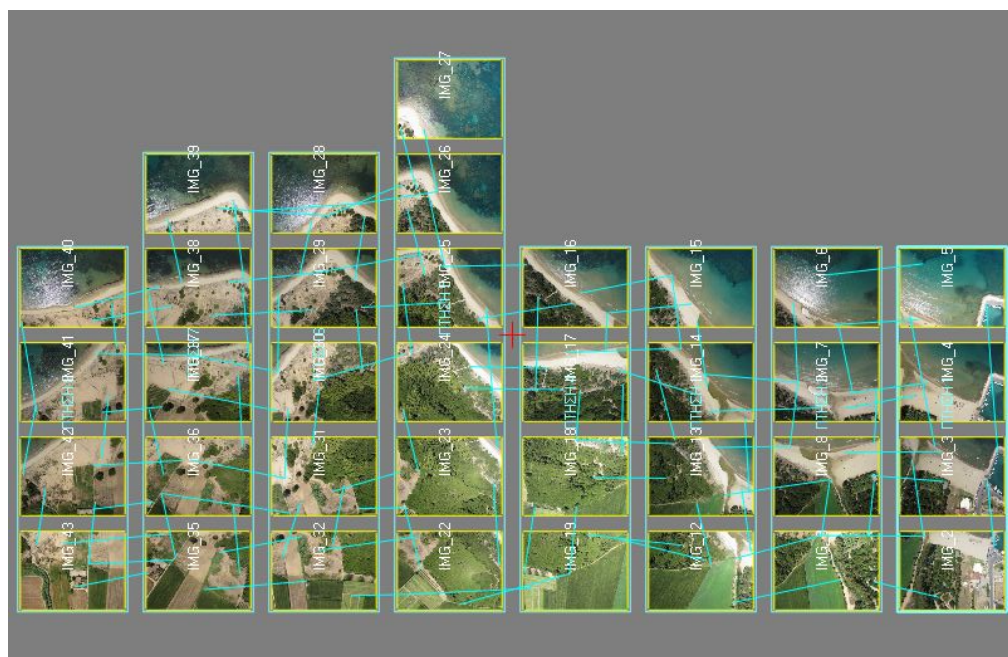
The UAV collected **52 images** so I had to choose **40** of them in order to work with **Photomod Lite**. So I chose the ones that covered the area of interest and I imported them into the project by strip. Although the auto pilot of the UAV has given me exterior metadata I preferred not to work with automated procedures but test my own power using **quick ties**. I began classify the images into the 8 strips and below I give you the result.

	1	2	3	4	5	6	7
ΠΤΗΣΗ 8	IMG_43 ↑	IMG_42 ↑	IMG_41 ↑	IMG_40 ↑			
ΠΤΗΣΗ 7	IMG_35 ↓	IMG_36 ↓	IMG_37 ↓	IMG_38 ↓	IMG_39 ↓		
ΠΤΗΣΗ 6	IMG_32 ↑	IMG_31 ↑	IMG_30 ↑	IMG_29 ↑	IMG_28 ↑		
ΠΤΗΣΗ 5	IMG_22 ↓	IMG_23 ↓	IMG_24 ↓	IMG_25 ↓	IMG_26 ↓	IMG_27 ↓	
ΠΤΗΣΗ 4	IMG_19 ↑	IMG_18 ↑	IMG_17 ↑	IMG_16 ↑			
ΠΤΗΣΗ 3	IMG_12 ↓	IMG_13 ↓	IMG_14 ↓	IMG_15 ↓			
ΠΤΗΣΗ 2	IMG_9 ↑	IMG_8 ↑	IMG_7 ↑	IMG_6 ↑			
ΠΤΗΣΗ 1	IMG_2 ↓	IMG_3 ↓	IMG_4 ↓	IMG_5 ↓			

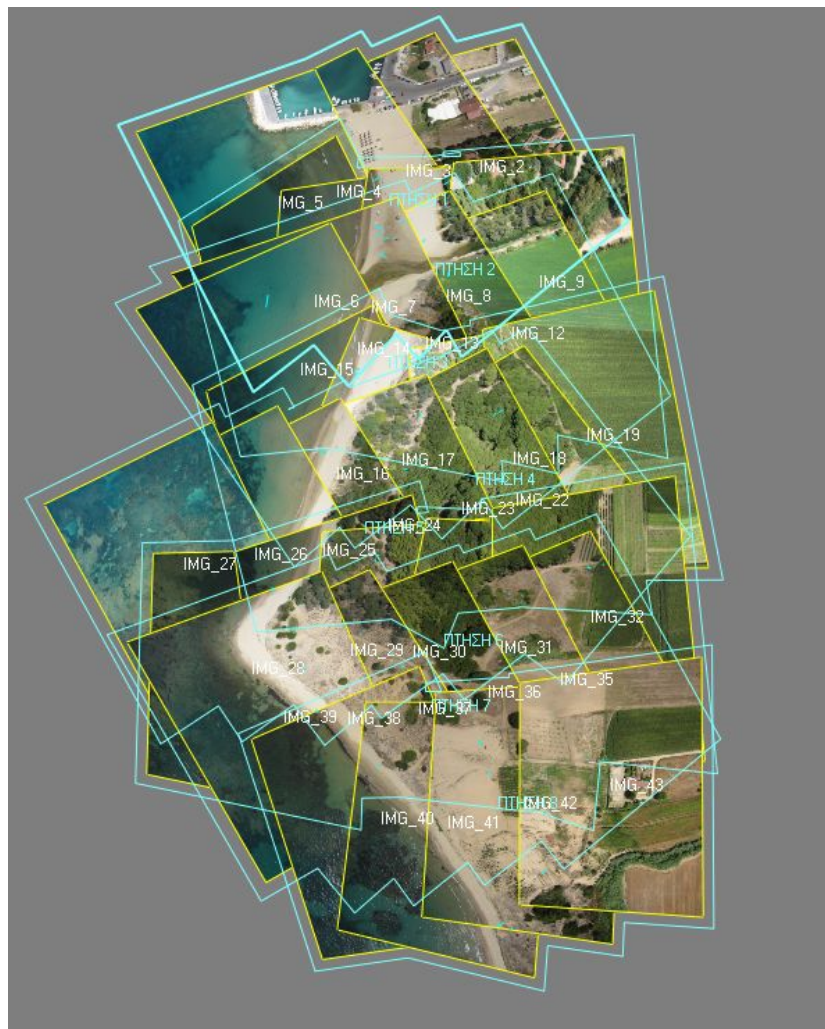
Strip: ΠΤΗΣΗ 1 [8/8] Image: Font size: 8

Pic 5 : Classification of images into strips

The next step was to correlate the images in each strip and the strips between them. I used the very useful 'quick ties' which gave me the sense of controlling the whole procedure (This is something you miss on automated procedures).



I imported the *.x-cam file of the camera, given by the manufacturer and I solved the interior orientation by assigning the **IXUS CANON 220HS** to the selected images without any problems. Here is the block layout after quick ties and interior orientation.



Pic 6 : Block layout after applying quick ties

In order to solve relative orientation I executed the automatic tie point measurement using the **UAV settings** with correlation threshold **85% in-strip and 80% between strips**. The report gave me good results only in individual stereopairs and many errors (not completed) in triplets and in the inter-strips measurement. So I started

to work the stereopairs one by one and adding tie points trying to keep the vertical parallax in low figures. This was difficult because the area on which the problem was intense was covered with trees and the correlation was very low. After a lot of effort and time I managed to unmark the errors but still I find some serious mismatches in z-factor.



Pic 7 : Block layout after finishing the relative orientation

As you can see from the image above, after solving the relative orientation there is a part of the area of interest which is covered by trees, has no gaps inside and it is inevitable to be very poor in tie points. In some places that I managed to find tie points the correlation threshold **was under 75%**. Below I give you one of the images in which I had difficulties finding tie points.



Pic 8 : Image taken by the UAV with 80% coverage of vegetation

Finally I imported into the project the 5 control points which was allocated around the perimeter of the forest and proceed to bundle adjustment in order to solve the exterior orientation. Below are the results of the adjustment.

Residuals	Residuals	Residuals
Ex, Ey, Ez, Exy (metre)	Ex, Ey, Ez, Exy (metre)	Ex, Ey, Ez, Exy (metre)
ground control	ground control	ground control
0.264 , 0.169 , 3.060°, 0.314°	0.233 , 0.115 , 2.371°, 0.309°	0.401° , 0.293 , 5.187°, 0.401°
check	check	check
tie	tie	tie
from mean	from mean	from mean
0.120 , 0.126 , 0.280 , 0.174	0.074 , 0.081 , 0.199 , 0.122	1.436° , 1.248° , 2.323° , 1.466°
mutual	mutual	mutual
0.167 , 0.201 , 0.417° , 0.261	0.110 , 0.136 , 0.295 , 0.193	1.995° , 1.783° , 2.553° , 2.074°
targeted	targeted	targeted
from mean	from mean	from mean
0.000 , 0.000 , 0.000 , 0.000	0.000 , 0.000 , 0.000 , 0.000	0.000 , 0.000 , 0.000 , 0.000
mutual	mutual	mutual
0.000 , 0.000 , 0.000 , 0.000	0.000 , 0.000 , 0.000 , 0.000	0.000 , 0.000 , 0.000 , 0.000
tie - projection centers	tie - projection centers	tie - projection centers
from mean	from mean	from mean
0.000 , 0.000 , 0.000 , 0.000	0.000 , 0.000 , 0.000 , 0.000	0.000 , 0.000 , 0.000 , 0.000
mutual	mutual	mutual
0.000 , 0.000 , 0.000 , 0.000	0.000 , 0.000 , 0.000 , 0.000	0.000 , 0.000 , 0.000 , 0.000
Sigma_0 = 5.470	Sigma_0 = 5.470	Sigma_0 = 5.470
RMS Mean abs. value Max	RMS Mean abs. value Max	RMS Mean abs. value Max

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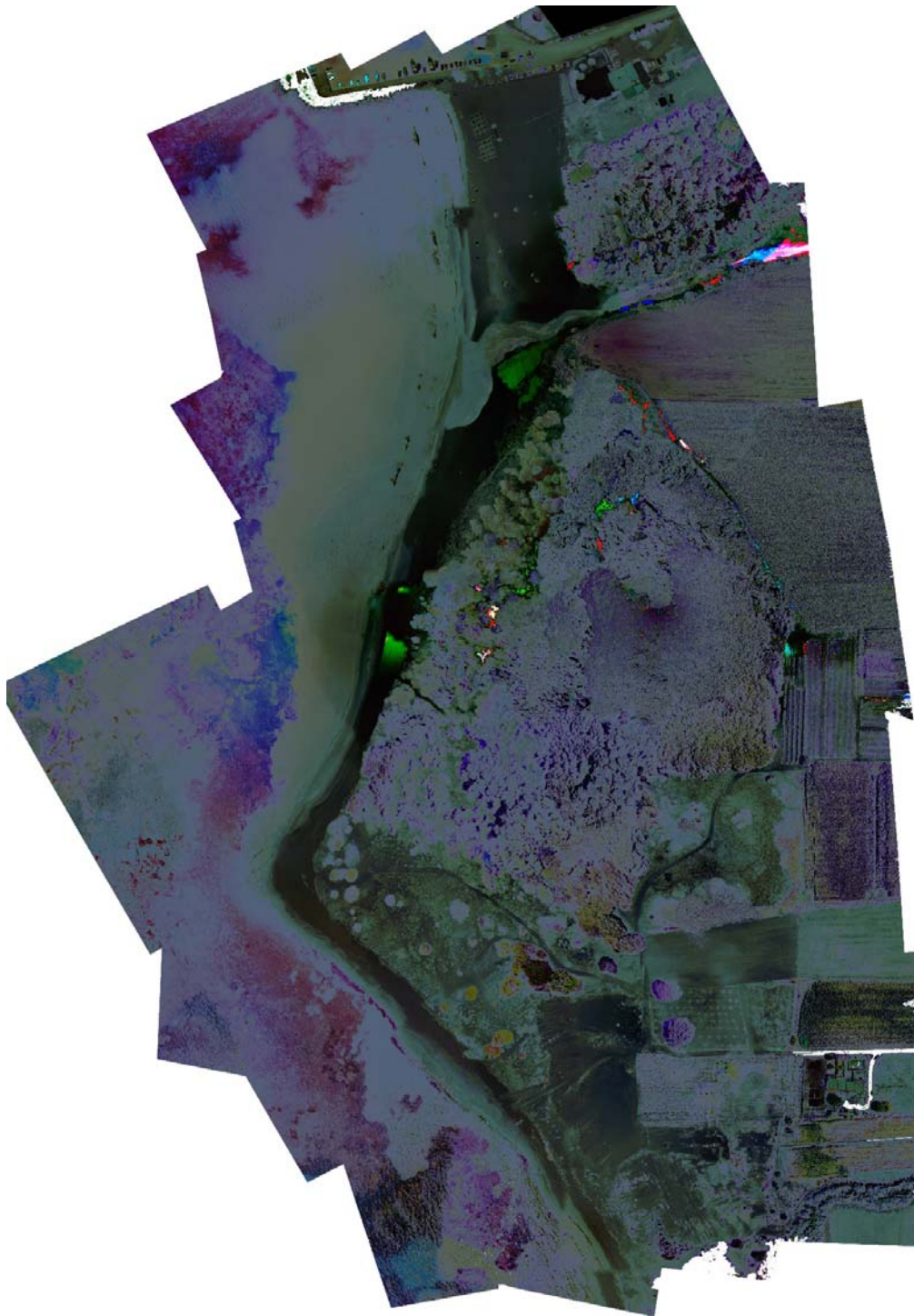


I used the Mosaic software in order to produce the ortho-mosaic of the forest using auto-build ROIs and average brightness. The area of interest has no great elevation differences so I used the elevation of 2 meters as fixed elevation for the creation of the mosaic.

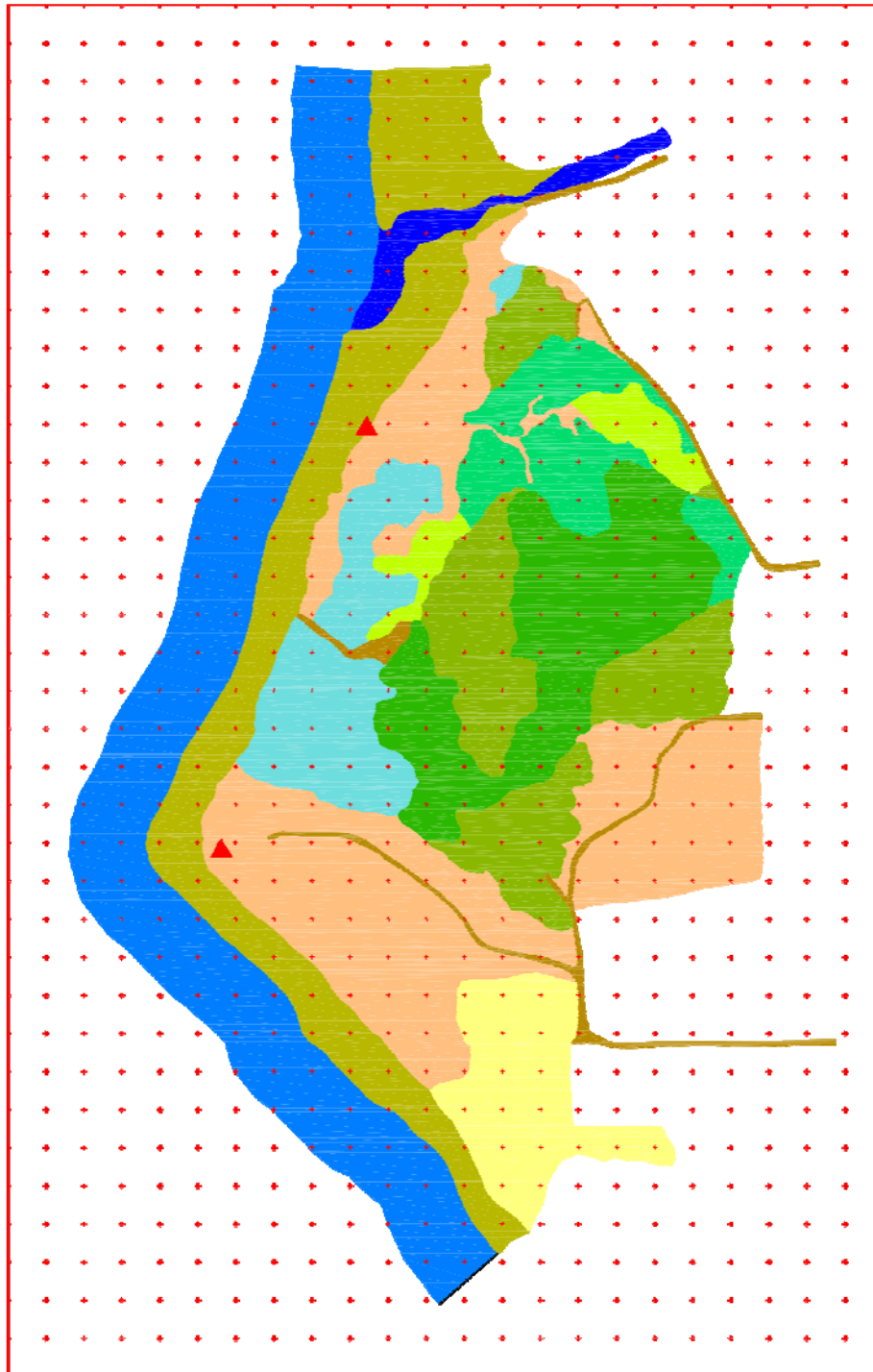


Pic 9 : Mosaic of the Palouki forest

In order to recognize and classify vegetation the produced mosaic is being elaborated with certain filters and further process with the **e-cognition** software.



Pic 10 : Mosaic after process with vegetation filters



Pic 11 : Vegetation map of the 'Palouki' forest