

## **A Visualization Tool For Forest Landscape Using Open Software**

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**ABSTRACT:-** The current paper presents the development of a visualization tool (EnvIn 3D 2015) for producing dynamic simulations of actual forested landscapes. The tool is based on the Unity engine and framework, a system for designing game or 3D app scenes. Specifically, this work involves creating a three dimensional interactive representation of a region through an application that enables the user to create a synthetic environment. The main difference from similar computing systems is that it puts the user at the center of activities. We describe in detail its construction and architecture, through the application to an actual forest landscape with thousands of trees to show how this system can be used to simulate the changes of forest landscapes that occur as a result of natural processes or man-made disturbances. Technologies such as Unity, and associated utilized add-ons have been chosen as the most suitable for the interactive visualization of the forest model.

**KEYWORDS:-** 3D Forest model, Unity, Forest landscape.

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### **I. INTRODUCTION**

Visualization of landscapes is nowadays a central part of forest landscape perception and research [1]. Building a unified database that can function as a platform for development within a forestry area can be considered to be as a major challenge (see, e.g. [2]). Three-dimensional imaging refers to techniques that create a three-dimensional model of a real object or scene, having as input two-dimensional images of the object or scene.

Three-dimensional (3-D) visualizations of forest landscapes are quantitative ecological information-based techniques that can be used to visualize forest structure, dynamics, landscape transformations and regional plans [3]. Over the last years, the improved capabilities of hardware and computer code have allowed us to simulate and visualize natural advanced forms such as plant growth as well as the effects of changes in region conditions and light-weight [4].

Modeling and real-time rendering of forest scenes based on real data is an important and challenging problem in computer graphics and geomatics [5, 6]. Besides the recent explosion of computer graphics however, only a few researches have investigated the possibility of utilizing 3D visualization techniques for representing real data of the forest and forest landscapes.

Under this perspective, this paper illustrates a 3D web-based visual simulation system, called EnvIn 3D 2015, that supports spatial-information based realistic modeling and real-time rendering of forest scenes. In particular, in the current study we have developed a forest landscape image system capable of walk-through simulation. By walk-through simulations, precise recognition is possible in choosing various plans. To verify the practicability of this forest landscape image system, we have visualized an actual forest landscape with thousands to tens of thousands of trees from Northern Greece.

The organization of the article is as follows. Section 2 outlines prior literature on research associated with attempts for the visualization of forest landscapes. Section 3 explains the data and methods employed. This is followed by the presentation of findings (Section 4). Section 5 discusses on the obtained results in line with earlier studies and concludes with some reflective comments and possible future research and implications.

### **II. LITERATURE REVIEW**

The use of 3 dimensional forest models for designing and management support, has been studied in literature in numerous situations like resource estimation in virtual tropical forest, datasets analysis for carbon estimation [7], as well as for directly forest trees management. Further studies have been performed to live forest indicators like plant growth through the readying of an ecological model [8].

Many researchers have developed algorithms for digital plant modeling [9, 10, 11, 12], and 3D digital plant modeling systems have been used to develop forest landscape visualization systems such as the AMAP

system [10, 13], the Vantage Point system [14, 15], and the Smart Forest [16, 17, 18]. These 3D visualization systems place individual trees on a digital terrain model (DTM) via a graphic user interface (GUI).

Zhang et al. [3] surveyed all the previous approaches for big scale rendering of forest environments and developed a brand new hierarchical illustration for a forest model that allows a quick display (real-time interactivity) of rendering with nice performance and sensible image quality as well as affordable knowledge storage value. Bao et al. [6] focus on increasing realism and period performance: developed new technologies to make giant (about 10 thousand trees) realistic rendering of advanced careful tree structure with advanced realistic illustration of shadows while not moving the interactive expertise of virtual surroundings exploration.

The validity of rendered forest was investigated since the 90s beginning with biology environmental planning, with prototypes of landscape mental image [15] and ecological modelling simulation at intervals a 3 dimensional model of the forest system [19]. In the optic of combining digital surface model of the forest area acquired from remote sensing surveys with 3D structural model of the canopy in the virtual environment, the accurate recreation of the trees was a crucial subject [20].

Honjo and Lim [21] developed a system for real-time rendering of landscapes using virtual reality modeling language (VRML). With their system, actual gardens with thousands of plants could be visualized in real-time in walk-through simulations on a personal computer. However, the system proved inadequate for the accurate presentation of forest landscapes, as forest data are generally managed not in units of individual trees, but in units of forest stands. Honjo and Lim [21] developed a forest landscape visualization system using virtual reality modeling language (VRML). The proposed visualization system worked with data of forest stands rather than individual trees.

In another study, Zhang et al. [3] use public data sources to visualize forest landscapes. Specifically, the authors used the Forest Inventory and Analysis (FIA) database and other existing vegetation data, classified Landsat TM imagery, measurements of tree architecture and Forest Vegetation Simulator (FVS) to visualize a forest landscape in the Washburn District of the Chequamegon National Forest (CNF) in northern Wisconsin.

In the last decade, forest visualization interfaces evolved from simple mapping into sophisticated systems characterized by 3D navigation, interaction and visualization. Several techniques for real-time rendering of terrain and forests have been studied in the past [22], going from planar tree billboards to more complex 3D models with lighting techniques [23] and new representation of canopy reflectance on steep terrains [24].

Pratihast et al. [25] developed an interactive web-based near real-time (NRT) forest monitoring system using three components: Web-GIS technologies, satellite and CBM data source and social media, with the goal of adding a tool for forest monitoring processes and providing up-to-date and accurate information on forest change.

### III. MATERIALS AND METHODS

#### A. The Unity framework

Unity is a 2D/3D engine and framework that gives you a system for designing game or app scenes for 2D, 2.5D and 3D. It allows one to import and assemble assets, write code to interact with various objects, create or import animations for use with an advanced animation system. Unity is a native C++-based game engine and has been utilized for the design and developing of training simulators, first-responder applications, and other business-focused applications that need to interact with 2D/3D space. Unity allows this interaction via not only code, but also visual components, and exports them to every major mobile platform. We refer the interested reader for a detailed description of the Unity engine at: <https://docs.unity3d.com/Manual/index.html>.

The general framework of the visualization procedure is described in the following figure (Fig. 1).

--FIG. 1 AROUND HERE--

#### B. Visualization of forest landscapes by combining UNITY with suitable add-on tools

The landscape 3D visualization tool is integrated within Unity engine and framework, a system for designing game or app 3D scenes. Its architecture is visually described through Fig. 1. In this paper the approach of combining Unity engine and its Assets (i.e. EasyRoads3D, Relief Terrain Pack, Terrain Composer, UniStorm Weather System, Advanced Artificial Intelligence Pro, KGF Map System) as well as Standalone software has been followed (i.e. Agisoft PhotoScan, SketchUp).

The landscape 3D visualization tool is integrated within Unity engine and framework, a system for designing game or app 3D scenes. Its architecture is visually described through Fig. 1. In this paper the approach of combining Unity engine and its Assets (i.e. EasyRoads3D, Relief Terrain Pack, Terrain Composer, UniStorm Weather System, Advanced Artificial Intelligence Pro, KGF Map System) as well as Standalone software has been followed (i.e. Agisoft PhotoScan, SketchUp).

This environment combined by the integration of the above tools allows us to develop an application that can be used for educational purposes, such as management bodies, environmental parks or archaeological sites. At the same time it can be used for recreational purposes such as skiers in ski resorts or nature lovers in general, giving them the opportunity to experience an area before practicing their favorite hobby, they can also for security reasons capture an area with the corresponding weather phenomena before find themselves there.

Lastly, this 3D visualization tool can be used for scientific purposes, for instance to assess the environmental impact of an anthropogenic intervention such as the re-presentation of an area after a catastrophic fire or the deforestation and dilution of the flora of a region.

### **1) Visualization procedure**

In the rest of the current section, the add-on's utilized for the purposes of our study and creation of EnvIn 3D 2015 is described in detail.

#### **2.1) Relief Terrain Pack**

Relief Terrain is a shader system which renders terrain and other objects with high-end shaders (<https://assetstore.unity.com/packages/tools/terrain/relief-terrain-pack-v3-3-5664>). Relief Terrain Pack allows creating quality terrains that are not possible to create with Unity's terrain editor alone. This pack allows creating advanced terrain geometry, such as caves, adds special quality shaders, and provides a large variety of terrain tools even for mesh terrains. It is a system that replaces shading pipeline of terrain surface. It is not "new terrain" system as it works on the top of Unity's built-in terrain. Terrain detail color coverage is taken from RGBA texture (called splat control) where R channel level means coverage of 1st layer, G channel of 2nd layer and so on.

One of the main Relief Terrain principles is a new layer blending method called height-blending. With height map blending we can command shader to decide where to show sand and where grass depending on their height maps which are set per layer. Another useful feature of Relief Terrain is the RTP\_LODmanager, which is basically an object that helps manage RTP shaders features.

#### **2.2) Easy roads 3D**

The EasyRoads3D v3 system is designed to minimize the amount of time one has to spend on setting up parameters and properties in the Unity Inspector for each road or crossing in the scene in order to maximize productivity (see <http://www.unityterraintools.com/tools.php> for more details). Specifically, Easy roads 3D is a Unity 3D asset for road infrastructures and parametric modeling inside Unity. It is used for creating unique road networks directly in Unity with built-in and mesh based crossings based on models that the user selects. Additional side objects that can be constructed include: bridges, guard rails, fences, walls, power lines, tree lines or any other type of geometry following a path. EasyRoads3D v3 includes various tools to create other infrastructures such as railroads and rivers with the riverbed carved in the terrain.

#### **2.3) Terrain composer**

TerrainComposer2 (TC2) is a powerful node based multi-terrain tile generator (<http://www.terraincomposer.com/terraincomposer2-documentation>). TC2 makes use of the latest GPU technology to give the user instant real-time results, which makes creating terrains faster and easier than ever before. TC2 its folder like layer system and workflow is similar to that of Photoshop, which makes it possible to have full control and make quick changes any time during the workflow.

#### **2.4) UniStorm weather**

UniStorm is a dynamic day and night weather system tool that creates special quality dynamically generated weather, lighting, and skies all at a blazing fast frame rate (<http://unistorm-weather-system.wikia.com/wiki/Documentation>). UniStorm features over 300 customizable components allowing users to create any environment imaginable. Additionally, the Time Options of Unistorm allows adjusting anything which is time related. This stands for Starting Time, Date, Day Length, Calendar Type, and more. Also, the Weather Options allows the user to control UniStorm's weather related variables. These include: Weather Odds, Particle Colors, Weather Fade Speeds, and more. Similarly, the Wind Options allow you to adjust UniStorm's dynamic wind settings.

#### **2.5) Advanced Artificial Intelligence Pro**

Advanced AI Pro, is a complete and professional AI (Artificial Intelligence) solution for Unity game designers, artists (non-programmers). It has the main features of any industry-standard enemy AI behavior, as well as neutral, and friendly/ally behaviors (see <https://forum.unity.com/threads/released-advanced-ai-pro-aaa-ai-solution.168870> for more details). The specific Unity Asset covers the following features: (a) Basic

pathfinding so that application characters can navigate a 3D scene realistically; (b) Patrolling, which extends pathfinding to have characters patrol routes in a scene; (c) Behavior trees, which may be used to give AI characters the ability to make decisions; (d) Sensors and activities, set up sensors and have AI characters change their activity based on what they sense in the environment; (e) Adaptation, which essentially corresponds on how to have AI characters react and adapt to different events in the scene; (f) Animation and AI, which integrates character animation with AI using both Unity's legacy and Mechanism animation systems; (g) NavMesh Generation, for setting up navigation meshes to handle mesh creation for different geometries and multiple NavMeshes in a scene.

### **2.6) KGF Map system**

KGFMapSystem is a complete and advanced MiniMap system for Unity 3d, with support for “Zoom”, “Rotate”, “Pan”, “Center map on Target” as well as other actions (<https://assetstore.unity.com/packages/tools/gui/kgfmapsystem-minimap-3977>). In this orientation map, both our position and the remarkable locations of the exploration area are mapped out macroscopically. It is a useful tool that helps us to orient ourselves in the area we are moving, and it makes it easy for us to choose our points of interest within our entire range.

### **2.7) Agisoft PhotoScan**

The 3D Model reconstruction of the buildings for the visualization system developed has been accomplished with Agisoft PhotoScan. Specifically, Agisoft PhotoScan is a stand-alone software product that performs photogrammetric processing of digital images and generates 3D spatial data and 3D buildings, to be used in GIS applications, cultural heritage documentation, and visual effects production as well as for indirect measurements of objects of various scales (<http://www.agisoft.com/features/standard-edition>). Wisely implemented digital photogrammetry technique enforced with computer vision methods results in a smart automated processing system through various case studies PhotoScan has been proven to produce quality and accurate results.

## **IV. RESULTS**

### **C. The Study area**

The developed landscape simulation environment is to be tested on the Lailias, Serres public forest is located north of the city of Serres at a distance of approximately 30 km, and extends to the western part of the Vrodous Mountain, which form the southern - southwest escapes of Mount Orvilos. In particular, the forest extends into an almost independent western branch of the Vrodous Mountain, named “Lailias”. The scenic appearance of the forest location is shown on the following map (Fig. 2).

--FIG. 2 AROUND HERE--

The average height above sea level is 1,275 m with less height being 700 m and higher being 1,849 m with prevailing altitudes between 1,100 and 1,500 m. The morphology of the area on which the Lailias forest extends is characterized by diversity with alternating almost regular exhibitions (mainly southern and northern) and gradients from smooth to almost steep from 10-80% (and rocky vertical positions). This morphology is created by three ridges (and two streams between them) that extend from the east (higher) to the west. The total area of the forest amounts to 3,243.94 ha and its distribution in terms of land use is shown in the following table (Tab.1) and in the corresponding map (Fig. 3).

--TAB. 1 AROUND HERE--

The area reproduced with the Unity based visualization program is 400 Ha, that is, a square frame of 2.000 × 2.000 meters. Within this wide area there are four main points of interest. The main and central point (1) is the ski area with the huts, the chalet and the track (Fig. 3). The second point (2) of interest is the refuge at 1,750 m southwest in a straight distance. The third point of interest is the wider area of the old settlement “Ano Lailias” located at a distance of 1,500 m westwards in a straight line from the ski resort. The last point of interest is the event venue or, otherwise, the square of the woodcutters. This area is used by the Vlachs as a place where various folklore events take place and is one kilometer away in a straight line from the ski resort.

--FIG. 3 AROUND HERE--

#### **D. Visualization of real forest landscape through the proposed tool**

A Digital Ground Model consists of a plurality of non-standard elevations, as well as discontinuity lines and brake lines that attribute the geomorphological and soil abnormalities such as road boundaries, building contours, water surface boundaries, embankments or embankments, steep falls, etc.

This section presents the production of a 3-D interactive depiction of the area described in the previous section. The application has been created from a computer (with the assist of the Unity program) and is interactive and three-dimensional in the sense that a person is immersed in the research area. It creates a virtual environment with the help of a digital terrain model. The collection of data for the creation of the Digital Terrain Model was carried out by means of a photogrammetric procedure in a 3D environment with stereoscopic aerial photographs as well as topographic maps of scale of 1:5,000 digitized by the spatial and in combination with the topographical diagrams of GY. Scale 1: 5,000 as well as a number of terrestrial photostable points, were measured with the Leica GS14 GPS Geodesic GPS.

The integrated background of the application was created by the digital terrain model, which in combination with orthophotomaps, through a process called “Draping image over D.T.M” (see Fig. 4).

--FIG. 4 AROUND HERE--

At the start of the implementation, we have the option of selecting a “start” mode and a range of options such as “Options”, “Help”, etc. (see Figure 5 below).

--FIG. 5 AROUND HERE--

--FIG. 6 AROUND HERE--

Initially, the program allows the user to select the browsing mode. If the “Fly scene” mode is selected then the area can be traced by a camera at a height of 300 meters from the ground surface (Fig. 6). The movement is done in all directions at two different speeds, at a slow speed of 20 mm per hour and at a fast 40 mm per hour. After macroscopically viewing the area to be browsed, one of the other scenes in fig. 6, namely 3 or 4, can be selected, which recreates the area of interest at different seasons of the year, which for our illustration is spring and summer respectively.

#### **3.1) Modeling Environmental features**

Three different features, soil, environment and climate were investigated to create the virtual reality environment. With the assist of both the management study of the area and on site autopsy, the soil characteristics (areas with rocks, arid, vegetation types) were created. The environment is distinguished in natural and man-made. For the mapping of the elements of the natural environment, such as the type of vegetation, the mixing percentages of the different species from the management study of the area were used as input data (Fig. 7).

Significant assistance at this point was provided by the photo-interpretation of recent orthophotomaps, which clearly distinguish Beech tree from the pine. More than 60 thousand Beech tree and pine trees were used for the visualization of the specific area (see Tab.2 for a brake-down of forest land use in the research area of Lailias forest according to species).

--FIG. 7 AROUND HERE--

--TAB. 2 AROUND HERE--

The following figure (Fig. 8) shows the enlarged area of research combined with the forest cover as presented through an approved management study of the Forestry services of Serres city.

--FIG. 8 AROUND HERE--

An issue that arises is how to mix and massively place such a large amount of information. The problem was solved with the aid of Terrain Composer (Fig. 9), which made it possible to create masks of similar stem characteristics to the extent that using the mixing curves according to the management plan achieved an excellent vegetative distribution close to the actual state (Fig. 10).

--FIG. 9 AROUND HERE--

--FIG. 10 AROUND HERE--

As far as shrubs and meadows are concerned, the management study and field visits have given the opportunity of a realistic imprinting.

--FIG. 11 AROUND HERE--

During the creation of the digital terrain model, all the existing streams are represented, however in the center of our area of interest there is a steady stream flowing in which the movement and the representation of its flow were made in a very graphic way (see Fig. 11).

An important element, in addition to the natural environment of flora, is fauna. Next to the stream with the permanent flow and near the abandoned settlement “Ano Lailias”, which is our third point of interest, there is a fenced area 10Ha inhabited by deer (Fig. 12).

--FIG. 12 AROUND HERE--

--FIG. 13 AROUND HERE--

The proposed visualization program supports animal recreation in a realistic way, for example by allowing them to move away when approaching them (Fig. 13).

### **3.2) Modeling time and weather changes**

Through the program, it is possible for this environment to have a time and calendar simulation, to alternate day to night with real shades and to determine the appropriate duration of the day and night according to the time and location, as well as to choose a specific season of the year.

Specifically, the day’s duration is set at 7 minutes and weather conditions alternate randomly in five different scenes such as rain or snow, storm or snowstorm - depending on outside temperature - fog, partly cloudy, cloudy. This way we do not know the weather conditions we will encounter. The temperature range varies from  $-17^{\circ}\text{C}$  to  $+15^{\circ}\text{C}$ , which is in relation to the meteorological data of the area (Fig. 14).

--FIG. 14 AROUND HERE--

It is possible to intervene in each of the above parameters. The amount of snow is determined by the user with an increase and decrease snowbar as shown in the following graph (Fig. 15). Fig. 16 shows the same area without snow cover.

--FIG. 15 AROUND HERE--

--FIG. 16 AROUND HERE--

### **3.3) Modeling acoustics of the environment**

The powerful simulation of the environment translates beyond visual sensation and acoustics. Ordinary sounds of a forest such as the sound of water from a stream, the rustling of the leaves, which becomes more intense when the wind is increasing, the sound of rain on the fallen leaves, the different sound of our footsteps on the asphalt than in soil or water, takes us into an original intravasogenic environment. At this point, it is possible to import sounds of more birds or animals, as well as some specific sounds such as the noise from a sawmill (chain saw).

### **3.4) Modeling movement of the traveler**

The speed of movement of the “traveler” includes simple walking at 7 mm per hour and running at 15 mm per hour. For a more realistic representation of the area, the traveler cannot climb up slopes with gradients of more than 80%, while his downward movement on similar slopes will decrease. The process of orientation in our area is done with the help of a map on which our main points of interest have been marked (Fig. 17).

--FIG. 17 AROUND HERE--

Signs that are scattered on both crossroads and points of interest are of great assistance in orientation, providing the appropriate information about the position of the observer and the distances (Fig. 18). An example of the original signs is shown in Fig. 19.

--FIG. 18 AROUND HERE--

--FIG. 19 AROUND HERE--

### **3.5) Modeling of buildings**

Three-dimensional imaging refers to techniques that create a three-dimensional model of a real object or scene, having as input elements two-dimensional images of the object or scene. The facades of buildings can be rendered with images to make their representation more realistic [26]. In such cases, the digital terrain model, the three-dimensional model of the object in a design package, is made and the images of its objects, e.g. building facades, roads, sidewalks [27].

We are interested in the three-dimensional production of a building, the high quality and the photorealistic nature of these models, without insisting on the accuracy of measurements and dimensions. With the assist of “Agisoft PhotoScan” and taking at least 80 rotary photographs of each building we created a cloud of points with the model of each building (Fig. 20).

--FIG. 20 AROUND HERE--

The great challenge in this process was to keep the detail of the three-dimensional models on the one hand, and on the other hand, to keep the program running despite the large amount of data. With SketchUp we undertake to reduce all of this large volume of triangles created by 3D model buildings from “Agisoft PhotoScan” (Fig. 21). Fig. 22 presents the chalet building in reality and as it was designed in the virtual environment through the application.

--FIG. 21 AROUND HERE--

--FIG. 22 AROUND HERE--

A similar representation of an existing building in the area is depicted in the following figs (Fig. 23 & 24).

--FIG. 23 AROUND HERE--

--FIG. 24 AROUND HERE--

### **3.6) Modeling of roads**

The representation of the roads was attributed with the utmost precision both to their technical characteristics and to the texture and type of road surface. The roads were designed by the digitization of the area's road network from modern aerial photographs. Then the road modeling created with the assistance of EasyRoads3D (Road infrastructures and Parametric Modeling inside Unity, Free version) Then we created a unique road networks directly in Unity with built-in and mesh based crossings based on our models. The developed tool manages to bring the real scenes alive with additional side objects: bridges, guard rails, fences, walls or any other type of geometry following a path. EasyRoads3D v3 includes various tools to create other infrastructures such as railroads and rivers with the riverbed carved in the terrain.

## **V. DISCUSSION**

Virtual reality is a human-computer interface that is characterized by a high degree of immersion and interaction designed to make the user believe as much as possible in the interaction environment and not just an outside observer. Essentially, through virtual reality, the computer and various complementary devices are used to create simulations of human experiences. The goal is to improve all types of communication between people, machines and other entities. Through virtual reality, the user, in a fully natural, instinctive and multisensory way, is given the ability to interact with a computer-generated synthetic environment, being immersed and achieving a sense of presence within that environment.

3D image of forest landscapes are most suitable to be utilized in order to perceive stand succession, landscape transformation, and regional designing, and to boost decision-making processes and forest management generally. Moreover combining 3D image of trees and system info with management practices permits the creation of realistic visual situations for forest management. A user-friendly framework is essential when dealing with mapping applications as the above, such as those in the forestry sector and the latest generation of 3D interactive applications are the ideal candidates for this task.

This paper has presented a developed interface applied to real use case scenarios and feedbacks from field experts, as an attempt to build a new user friendly integrate system. The developed tool was illustrated through its application to an actual forest landscape with thousands of trees to show how this system can be used to simulate the changes of forest landscapes that occur as a result of natural processes or man-made disturbances. This has resulted in a virtual reality environment in which the user enters and tours the site. The developed tool is called EnvIn 3D 2015 from the initials: Environment Interactive 3D.

The use of such application software not only reproduces what is conventionally true, it also offers to the user the opportunity to create a synthetic reality, a synthetic environment. The key difference between this software and other related software programs is that the user is placed at the center of the activities and is organized based on the user's sensations. It also provides us with the opportunity to create, manage and process 3-D image objects. The program has been produced on a pilot basis for one area of investigation, i.e. the Lailias forest in Greece, in an effort to promote a developmental plan for this purely tourist area.

## **VI. CONCLUSIONS**

Advances in computer data visualization in the past 30 years have opened new opportunities for natural resources studies and in particular forest environment. This paper examined the suitability of Unity technology for its ability to create a three-dimensional natural but also anthropogenic environment to portray reality as close as possible, with the addition of suitable assets.

Specifically, this work involves creating a three dimensional interactive representation of a region through an application that simply does not reproduce conventional reality, but enables the user to create a synthetic reality, a synthetic environment. The main difference from other computing systems is that it puts the user at the center of activities. It also provides the ability to create, manipulate and edit 3D virtual objects. It was piloted for a research area of Lailias forest and mainly aims at the development of a mainly tourist area. The application of the visualization tool to a very large landscape with about 95,000 ha and a dense forest coverage was successful. Future research will address the improvement of rendered vegetation quality. In particular, the research will aim at the inclusion of more detailed biometric characteristics in the rendered models.

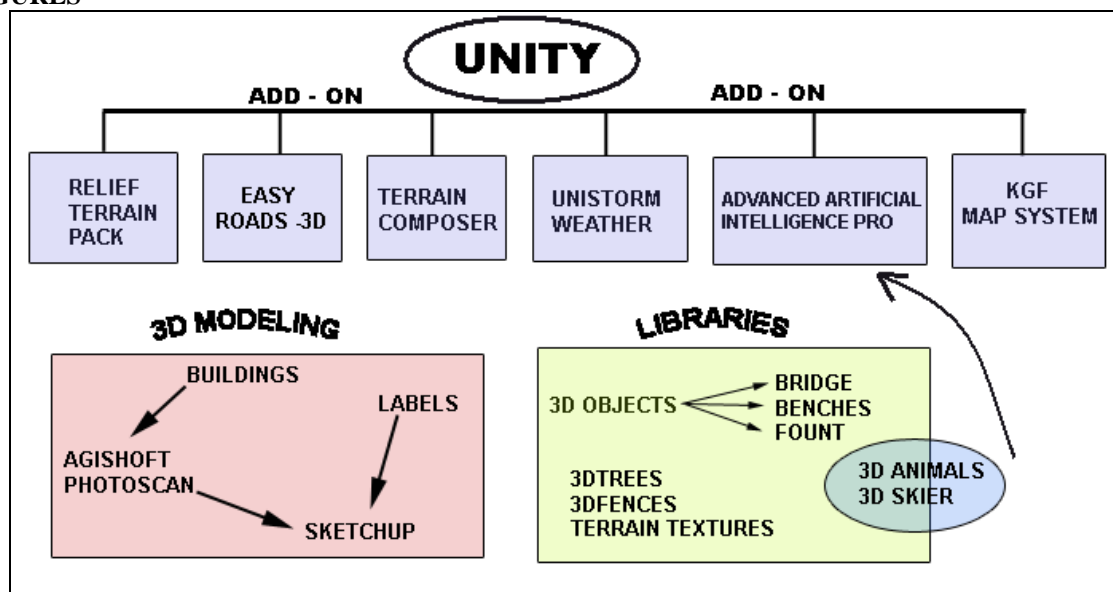
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**FIGURES**



**Fig. 1: Overall schema of the forest landscape visualization tool.**

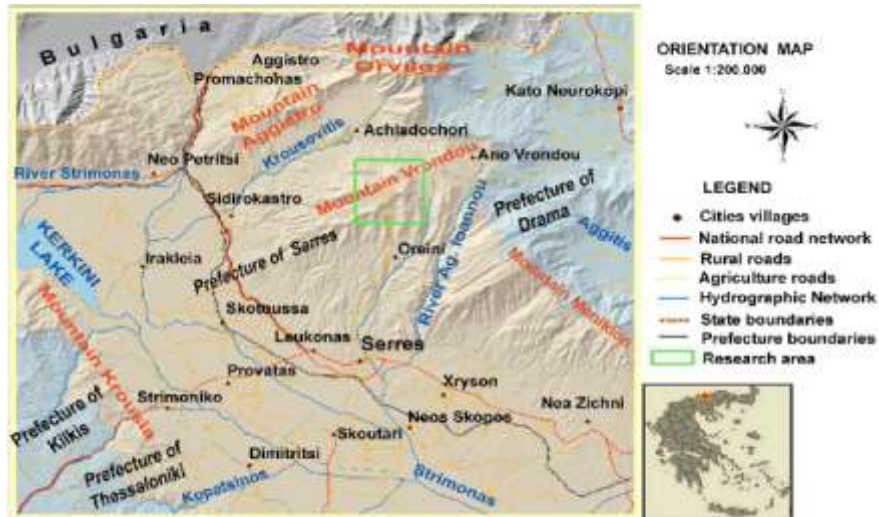


Fig. 2: Map of study area (Lailias public forest, Northeastern Greece)



Fig. 3: Part of the forest land that visualization tool utilizes.

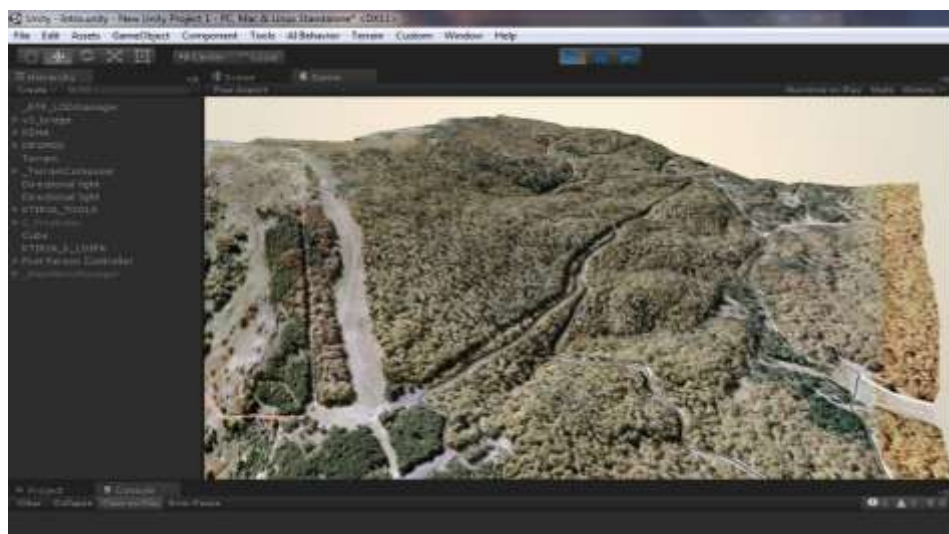


Fig. 4: Browse in the Fly Scene mode.

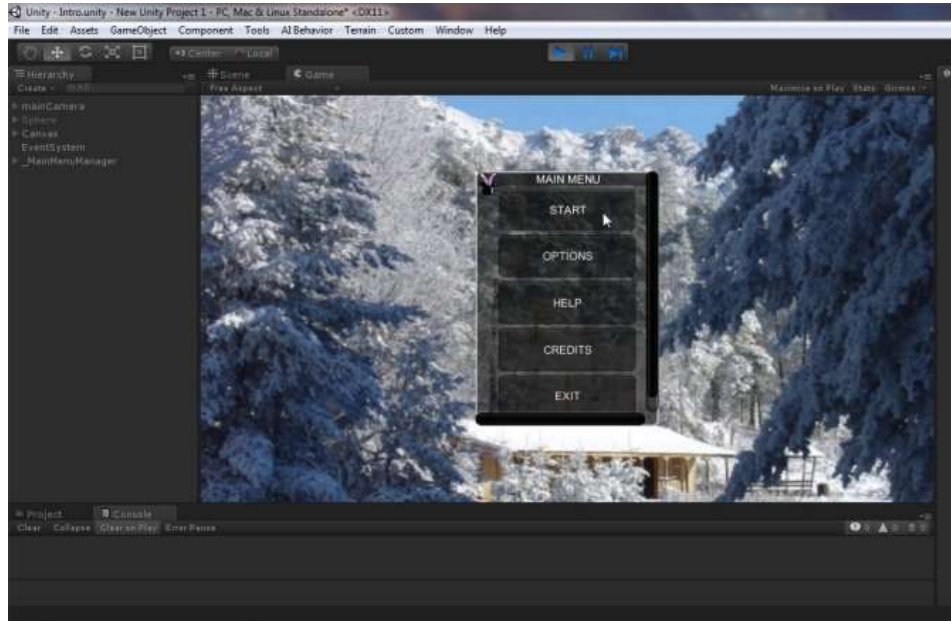


Fig. 5: Main “launch menu” of the application.



Fig. 6: Opportunity to select among the alternative scene modes.

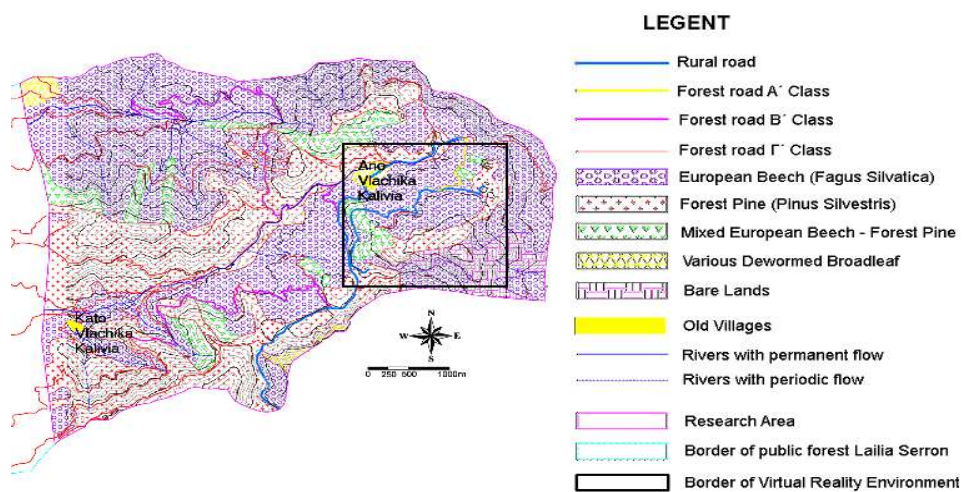


Fig. 7: Forest land survey area of Lailias, Serres.

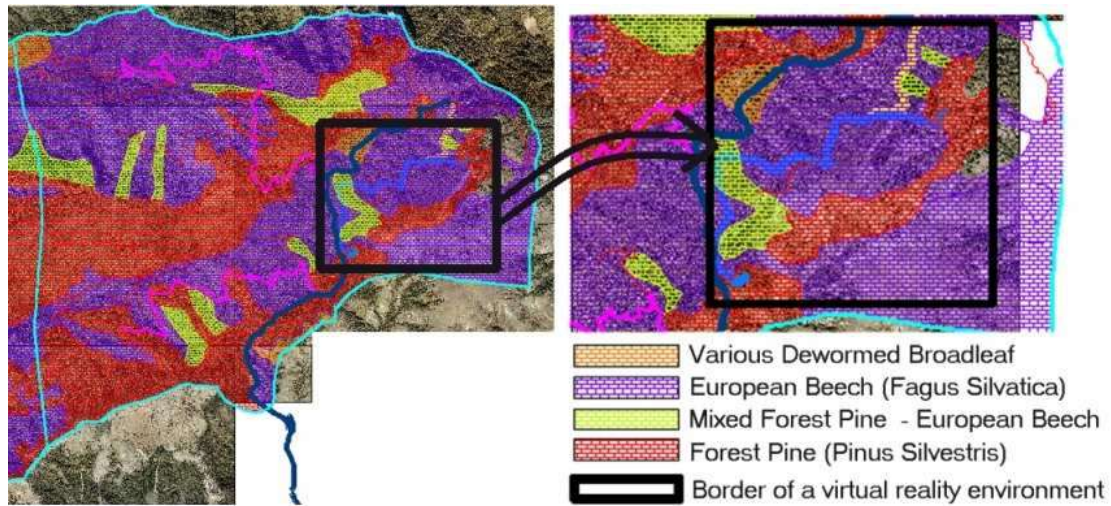


Fig. 8: Limits of the browsing area of interest.



Fig. 9: The "Terrain Composer" program.

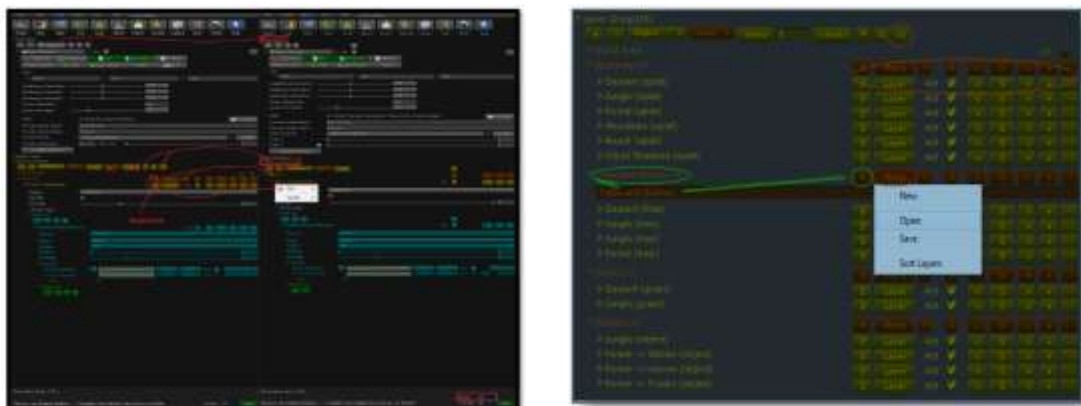


Fig. 10: The mixing curves for the vegetative distributions.



**Fig. 11: Comparison of representation between real and virtual impressions of the same area**



**Fig. 12: Fenced deer area**



Fig. 13: A characteristic “frame” of the virtual tour of the deer area.



Fig. 14: Windows for date control, weather conditions, temperature, light intensity.

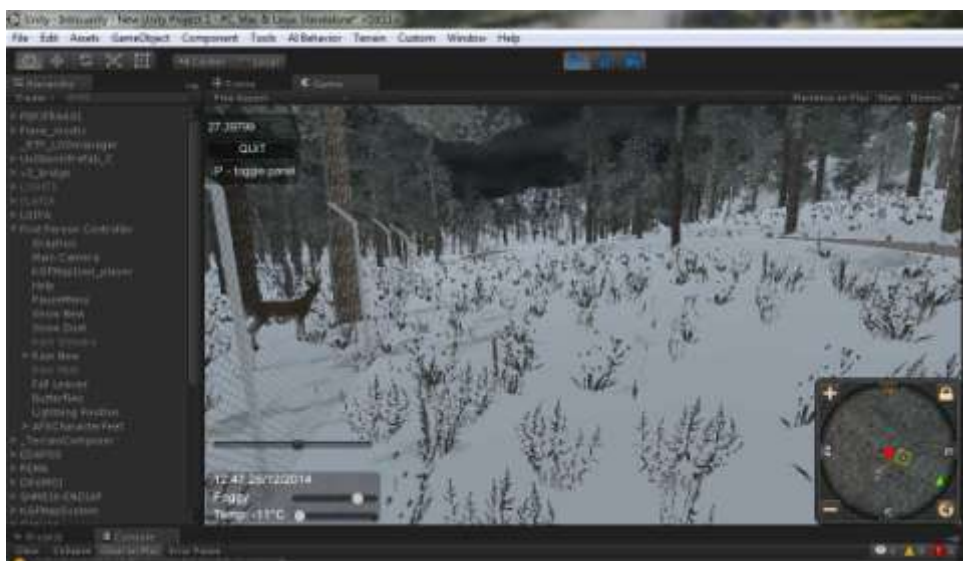


Fig. 15: Representation of an area covered in snow.



Fig. 16: Representation of the same area without snow.

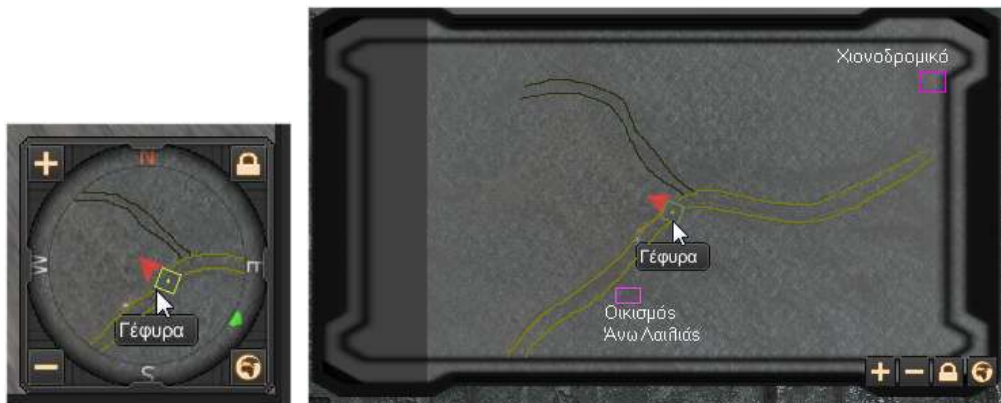


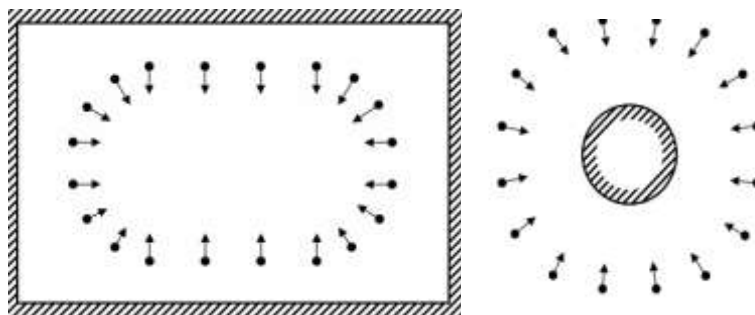
Fig. 17: The orientation map in extended and collapsed form.



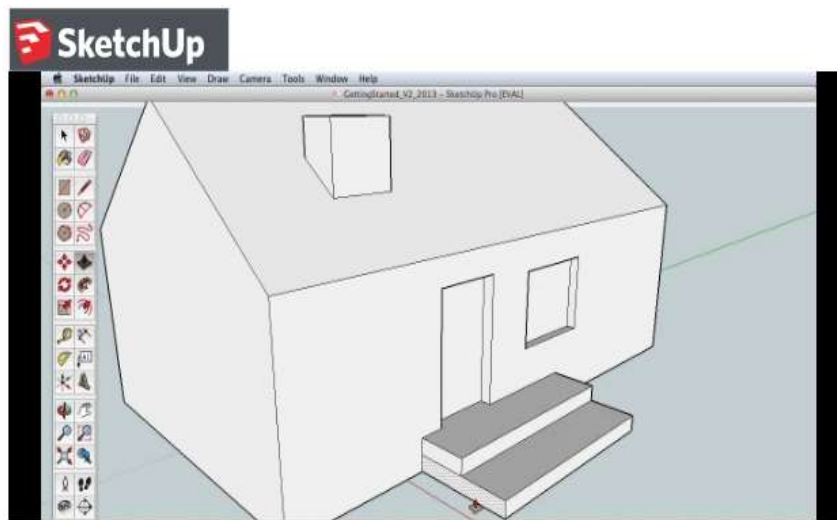
Fig. 18: Characteristic “frame” feature of the virtual tour of the enclosed area with the orientation plates.



**Fig. 19: Image of the same area as the orientation plate.**



**Fig. 20: Cloud of points for the modeling of the internal and external places**



**Fig. 21: 3D models as recreated with "SketchUp" program.**



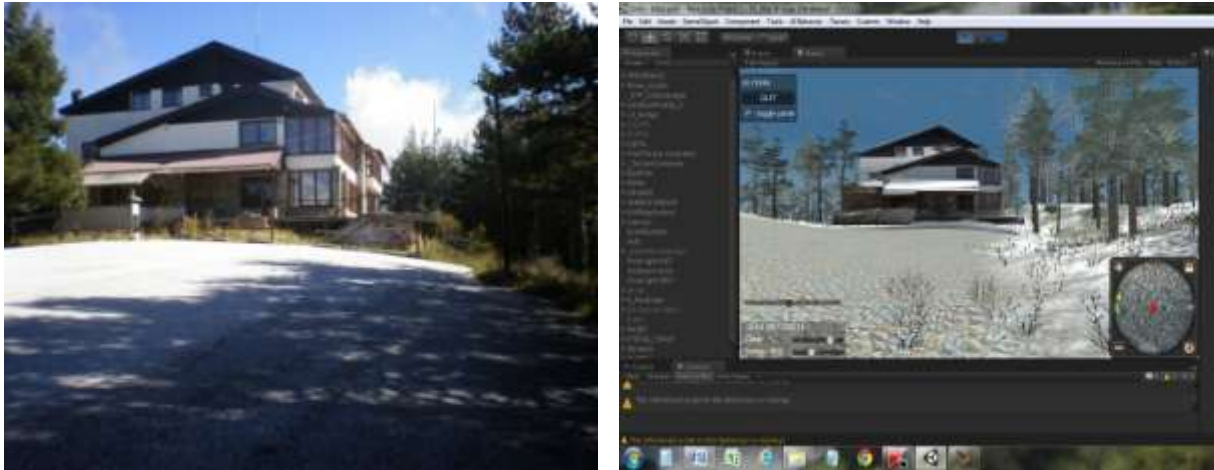


Fig. 22: The building of the Chalet (left) and the building as created with “SketchUp” and “Agisoft PhotoScan” (right)

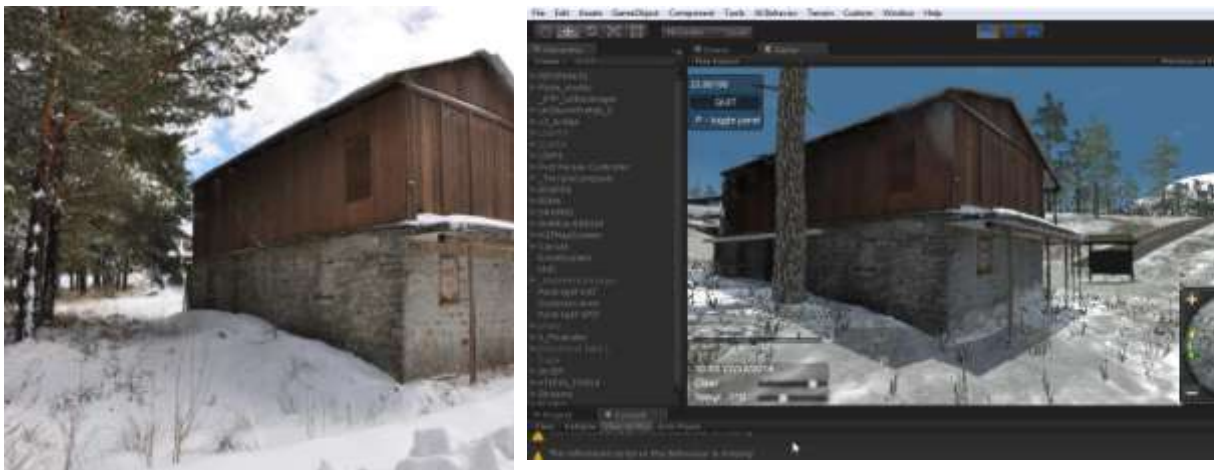


Fig. 23: Forest house next to Chalet in its natural environment (left), Forest house near the Chalet as was created with the use of EnvIn 3D 2015 (right)

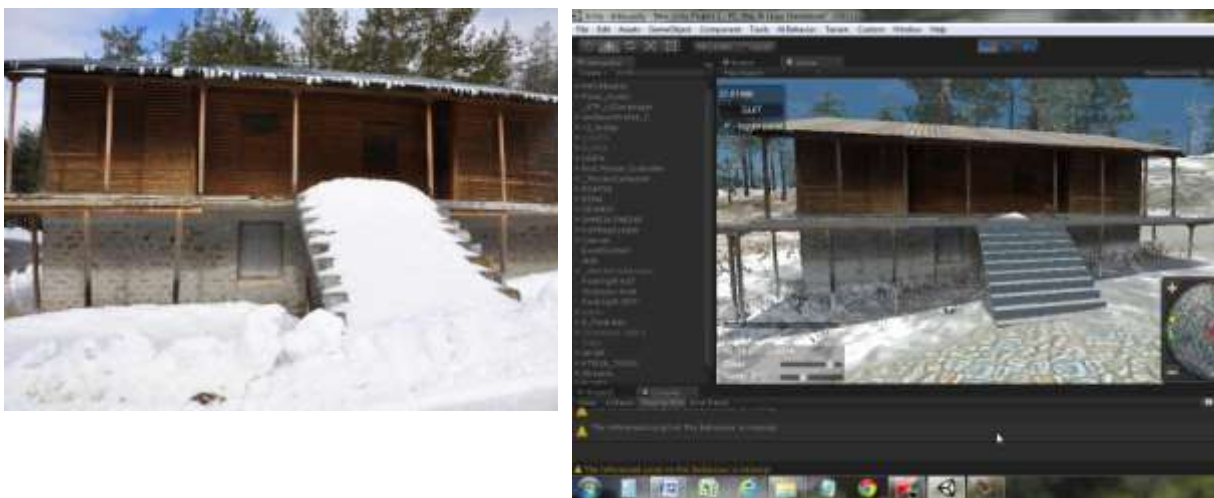


Fig. 24: Forest house as viewed from the northern side (left), Forest house as viewed from the same angle and created with the use of EnvIn 3D 2015 (right)

**TABLES**

<b>Land use</b>	<b>Area (Ha)</b>	<b>Percentage (%)</b>
Forest	2,718.02	83.79
Partially overgrown land fields	182.28	5.62
Agricultural and horticultural crops	-	-
Bare land fields	181.48	5.59
Arid land fields (rocky-river-lakes)	162.16	5.00
<b>TOTAL</b>	<b>3,243.94</b>	<b>100</b>

**Tab.1: Forms of land use of public forest of Lailias, Serres**

<b>Land use</b>	<b>Area (Ha)</b>	<b>Percentage (%)</b>
Oak Tree ( <i>Fagus Silvatica</i> και <i>Fagus Orientalis</i> )	180	45
Forest Pine ( <i>Pinus Silvestris</i> )	48	12
Mixed Oak – Forest Pine	72	18
Cities/villages	20	5
Arid land fields (rocky-river-lakes)	80	20
<b>Total</b>	<b>400</b>	<b>100</b>

**Tab.2: Forestry species in the research area of Lailias forest.**

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