

***Karten von Attika* : a major German contribution to Greek Cartographic Heritage and its digital approach.**

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Abstract. During the second half of the 19th century an interesting cartographic “interplay” takes place between Greece and Germany, within a broader context of an already well-established greco-germanic cartographic tradition. A prominent work in this 19th century cartographic co-operation is the so called *Archaeological Mapping of Athens, Attica and their surroundings*, by E. Curtius and J.A. Kaupert (1862-1897). The work, entitled “Karten von Attika”, is actually a sequence of map series compiled in three different scales; the maps are basically topographic, but they also include a vast amount of other information such as: geophysical form, settlements, roads, ports, quarries, forests, as well as archeological information in an impressive degree of detail. Although the value of this work is acknowledged in literature, having been recognized as a cartographic project of high quality, there is hardly any digital approach, concerning the treatment, elaboration and evaluation of the maps' geometric infrastructure and content. In our work we attempt to establish a framework for the digital approach, concerning a number of major topics of interest emerging from this monumental cartographic work.

Keywords: archaeological mapping, Attica maps, German maps of Greece, Greek state cartography

1. Introduction

A critical period within the history of Cartography is the 19th century, where the establishment of national states is interrelated with the developments in national mapping, which, in turn, are boosted by the scientific and technical dynamism of that period.

Within this context, an interesting cartographic “interplay” is taking place between Greece and Germany, during the second half of the 19th century, a prominent work of which is the so called *Archaeological Mapping of Athens, Attica and their surroundings*, by H. Curtious and J.A. Kaupert (1862-1897), in cooperation with the German Archaeological Institute.

The work, entitled “Karten von Attika”, consisted of 32 map sheets in scale 1:25000 (and four in scale 1:12500), accompanied with 10 map sheets in scale 1:100000, derived by photomechanical reduction. The maps are basically topographic, but they also include a vast amount of other information such as: geophysical form, settlements, roads, ports, quarries, forests, as well as archeological information in an impressive degree of detail.

The value of this work has been properly acknowledged in literature (see e.g. Livieratos, 2009; Korres, 2008): it is recognized as a cartographic project of high quality, regarding its technical specifications such as, for instance the manner of division in map sheets (neatlines and numbering), the legends etc.; its compilation of archaeological and historical information, in particular, is characterized as unprecedented, even until our days. Additionally, it has to be considered that: a) since this 19th century project, there hardly has been any other systematic cartographic work in Greece at this very important scale of 1:25000 and b) the area depicted has changed dynamically and dramatically during the last century, especially from the land-use point of view.

Nevertheless, there is hardly any cartographic digital approach, concerning the treatment, elaboration and evaluation of the maps' geometric infrastructure and content. In our work we attempt to establish a systematic cartographic framework for the digital approach, having in mind a number of major topics of interest emerging from this monumental cartographic work. More specifically:

1. It is recognized that the accuracy of the cartographic product is remarkable, considering its time and scale. In our work we try to demonstrate this in a quantitative way, by establishing a proper georeferencing procedure for map-sheets.

2. Natural elements such as the relief, but also other important features, such as forests and vegetation, can be optimally compared to their current counterparts using a modern map; because of the excessive urbanization and all kinds of changes in the area during the last century, such comparisons are of particular significance for the area's environment.
3. The monitoring of the changing land-use with emphasis on urban expansion is also a matter of study, using additional cartographic and photographic material for the extraction of useful results.
4. Finally, the archaeological information -extremely important for this part of the world- and the way it is depicted on the maps constitutes a real model example, which is hardly found on any other similar map of the area, even until our days. This rich information can still be used on modern thematic maps and digital representations for giving valuable overviews of the archaeological heritage in a quite detailed manner, provided through the many types of historical and archeological data of the maps.

Attica is a significant area, a central part of the world's cultural heritage and the model way it has been mapped by the German Archaeological Institute, J.A. Kaupert and E. Curtius has been an object of study for many years in different scientific projects in a traditional way; the effort for a systematic cartographic digital analysis and evaluation attempted here, will hopefully give the possibility of new historical, educational and technical approaches.

2. A German contribution to Greek 19th century cartographic heritage

The Modern Greek state was established in 1830, when Greece gained its independence from the Ottoman Empire. An urgent need, from its very beginning had been the development of national mapping, not only for the obvious reasons (administration, government, public works, taxation etc.) but also due to the fact that the new state came into existence after its liberation from the Ottoman Empire, which had a completely different policy regarding matters related to land (ownership, tenure etc). Establishing a national mapping authority was therefore of primary importance. An adventurous, cartographically speaking, period covers the first century of the new state's existence (Livieratos 2009), with both achievements and failures, regarding expectations related to the country's national mapping. A very brief overview -as constrained by the scope of this

work- is given in the following, in order to link to points related to the project presented here.

During the 19th century five milestones can be distinguished among the efforts made to map the Greek state (either by Greek governments or foreign missions in Greece), but also in the efforts to introduce the appropriate institutional structures for this purpose (Livieratos et al. 2010, Livieratos 2011). These are:

- The French Morea Expedition (1828-1850).

Starting in 1828, after an invitation of the first Governor of Greece, I. Kapodistrias, the French cartographic mission is planning a new map of Greece. However, this plan is changed due to French politics in this unstable area and the cartographic works are conducted by the French. In 1832 a map in six sheets and in scale 1:200000 is issued in Paris; this map will be sent to the Greek Government in 1834, for use by the newly established Greek state. In 1833 some more territories will be mapped and finally in 1852, the mission will be accomplished with the first map of the independent Greek state, issued in Paris, in twenty map sheets, in scale 1:200000.

- The German Archaeological Expedition (1862-1897)

Although the German cartographic presence in the new Greek state during the second half of the 19th century has its origin in matters of archaeological and historical interest, its contribution to the topographic mapping of the area is extremely important. This significant work starts in 1862, when the German Professor Ernst Curtius (1814-1896) and the major of the Prussian Bureau of Staff C. von Stranz, conduct a surveying of the area of Athens and its surroundings of Attica; this work will result in the creation and printing, in 1868, of the seven maps of the "Topography of Athens", in scale 1:25000. Shortly afterwards, in 1874, the German Archaeological Institute (Kaiserlich Deutschen Archaeologischen Institut) is established in Athens, supporting the topographic survey of Attica in scale 1:25000 under the supervision of Lieutenants Kaupert and Alten. More details of this project are given in a following section of the paper; it is however worth mentioning at this point that the geodetic and topographic work of the Germans in Attica is completely new, independent of the previous one carried out by the French and of very high standards. The work is based on a new established network of 30 points and on the measurement of a base along the Athens-Piraeus railway line.

- The Kokkides - Kiepert map (1884-85)

In the year 1881, the area of Thessaly is incorporated to the Greek state. This is followed by the production of the map series of the so-called "General Karte des konigreiches Griechenland" (Map of the Kingdom of

Greece). This map is engraved and printed in Vienna, in 1884, at the famous *Kaiserlich und Königlich Militärischen Geografischen Institut*. The map series consists of 11 sheets in scale 1:300000; it is based on work conducted by Kokkidis and Kiepert.

- The land survey and mapping of Thessaly (1887-1889)

A Greek cartographic expedition for the mapping of Thessaly starts in 1887, resulting after two years in maps in scales 1:50000 and 1:100000.

- The foundation of a state military cartographic institution (1889-1897).

In 1889 a national mapping service is established in Greece, in cooperation with Austrian experts. Maps are issued in scales 1:75000 and 1:200000 and 1:420000. A prominent example of this period is the Austrian series of the Generalkarte in scale 1:200000, adapted and used as a cartographic tool for the new parts of the Greek state in the north (Boutoura et al., 2010, Koussoulakou et al., 2011).

In contrast to the French, British or Austrian, the German cartographic presence in Greece (1862-1894) seems to cover only scientific and intellectual fields, having in mind not financial or investment issues, but rather the archaeological research (Livieratos, 2009). This is certainly in line with a long European tradition in the area, starting from the 15th century with the Florentine Cristoforo Buondelmonti, and lasting until the 19th century with the numerous travelers and philhellenes.

It should be noted here that a broader and longer context between Germany and Greece exists, with respect to cartography and mapping: it starts from the 16th century with editions of Ptolemy's *Geographia* influenced by Waldseemüller and Münster and continues until the 19th century (see e.g. Livieratos, 2001).

Among the cartographic milestones of the Greek 19th century, the one of the German Archaeological Expedition is of particular significance for the new state. The moving force behind the establishment of the German Archaeological Institute in Athens, in 1874 was Ernst Curtius, historian, surveyor, archaeologist and Professor in Berlin and Göttingen, also responsible for the excavations in ancient Olympia that started in 1875. Curtius was a typical Prussian philhellene of the era, who believed that the achievements of ancient Greece must set the measure for modern culture and society. At the same time there was a firm belief among many German archaeologists and politicians that in the field of classical studies the Germans should surpass the French, already established in Greece in that respect and also that the study of classical monuments should not be left to the French and British only. So Curtius convinced the chief of Staff of the Prussian Army General Helmuth von Moltke that it was necessary to

conduct a complete survey in Attica for the production of topographic and archaeological maps and to provide Johann August Kaupert - serving in the Army General Staff as a surveying expert- for that purpose. After the establishment of the German Archaeological Institute in Athens one of the first projects was the mapping of all the antiquities of Attica. But since the Greek state did not have any suitable base maps to support such a project, the Germans proceeded with the ambitious plan of creating themselves the cartographic background for the country, despite the time and effort necessary for such an undertaking. At the same time there was a cartographic work of that nature in progress in Prussia; thus the mapping of Attica was carried out within that context. The work was conducted in the years 1875-1894. Because of the nature of the work, but also due to the changing circumstances and conditions, the maps were made in many steps and additions; the final work, however, is consistent and in accordance to its initial purpose. In 1878 a twelve sheet map is issued, in scale 1:25000 (*Atlas von Athen*). When this work expands and covers all of Attica, in combination with the previous work by Curtius, the series of the *Karten von Attika* map is compiled, consisting of thirty-two sheets (sc. 1:25000), with four additional (sc. 1:12500) and one sheet (Thebes sc. 1:50000), completed in 1894. From this work a series of ten map sheets of the *Karten von Attika* in scale 1:100000 are derived (after photomechanical reduction and the addition of information from British naval maps) depicting Boeotia and Aegina. This monumental work will serve well until the 1930s, a fact that proves its solid scientific basis and value.

The production of the maps and the accompanying books was conducted in parts, namely in: 1878, 1881, 1883, 1885, 1887, 1889, 1893, 1894, 1895, 1900, 1903-1904 (Korres 2008, Livieratos 2009)

The final work consists of the following (see also *Figure 1*):

- 26+2 maps sheets (54 x 58 cm), numbered in latin numerals. The sheets I and II are in scale 1:12500, the sheets III-XVI in scale 1:25000. The two additional sheets mentioned here, are actually the sheets I and II with additional archaeological information shown on them.
- 11 smaller sheets (28 x 29 cm), numbered in common numerals, in scale 1:100000
- 1 large map for the whole area (81 x 103 cm), in scale 1:100000
- A volume with explanatory text and index (31 x 23 cm, 280 pages)

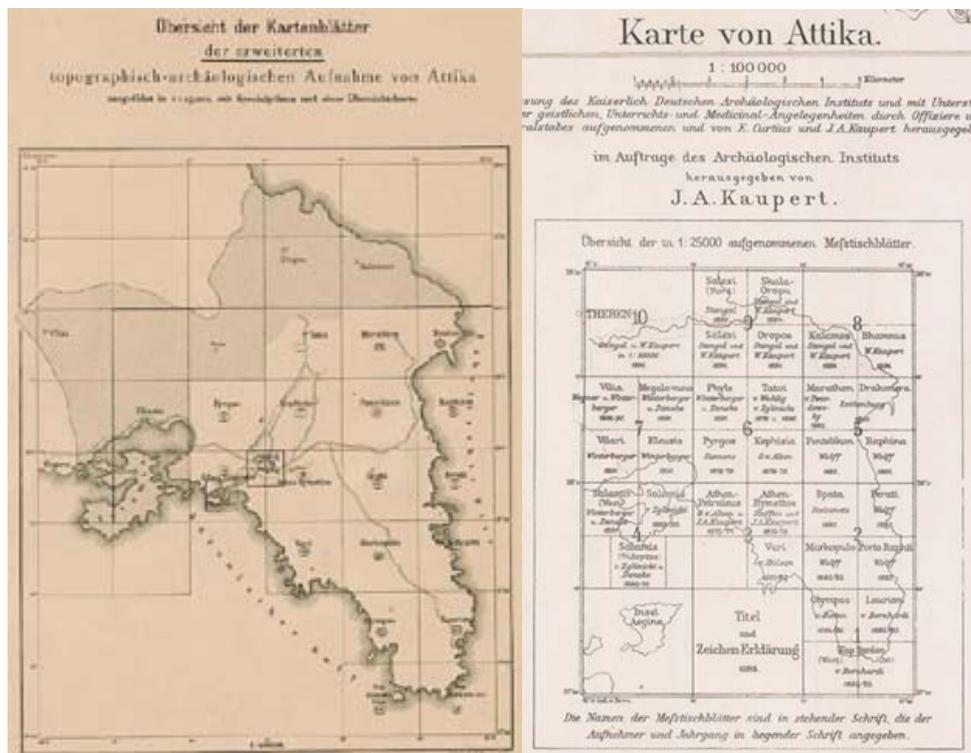


Figure 1. The map-sheet division of the Kaupert map for scales 1:25000 and 1:12500 (left) and for scale 1:100000 (right) -see text for explanation.

3. Establishing the digital approach

The German Archaeological Expedition constitutes a major step in the cartographic history of Greece; furthermore it is characterised by a number of particular achievements.

Until the mid-19th century the base maps of the new state were in rather small scales, namely 1:400000 and 1:200000, mostly made by foreign expeditions in Greece (French and German). These (with some additional hydrographic maps issued by the British Admiralty) will be the only available national maps for Greece, until 1877 (Livieratos, 2009). The basically German administration of the new state (under king Otto I) did not succeed in establishing a systematic national mapping, for a variety of reasons. In the 1870s the country expands its territory to the north (Thessaly); the new map series, depicting the Greek-Turkish border, are

now made in a larger scale (1:50000) and produced in cooperation with British officers. During the last quarter of the 19th century more maps are issued, ranging in scales from 1:420000 to 1:200000 (with the Austrian series of the Generalkarte in scale 1:200000 as a prominent example). Finally map series in a larger scale (1:75000) are produced by the newly established (1889) Greek national mapping institution.

Within this context, the German mapping project has been unprecedented, concerning the scale of the maps, even until our days. With the exception of a limited and fragmented work with topographic maps in scale 1:20000, carried out by the Greek Geographic Military Service (GYS) in the early 20th century (see GYS 1989, Baletti et al. 2010), there hasn't been any systematic cartographic work in Greece at this very important scale of 1:25000, since this 19th century German cartographic project.

On the other hand the area of Attica has always been a central place in the Greek world from many points of view. Its remarkable geographical location, combined with an exquisite climate have fostered the development of life and civilization since thousands of years; the place has always been an area of activity, development, but also exploitation and occasionally of extended environmental degradation, with the current situation being a prominent example of the latter.

The area, a cradle of civilization since antiquity and since the Renaissance a place of renewed inspiration for culture and humanistic values is continuously a spot of interest for literature, arts, political history. But apart from these, there are also more topics attracting interest, such as the natural and historical frame of the place, considered as the settings that enhanced the development of thought, culture and civilization; therefore the study of the landscape from the point of view of historical topography remains of interest: relief, natural resources, hydrology, geology, road network, geopolitical and territorial matters in its history constitute important topics for study.

It was only when large technical works were carried out (e.g. highways, metro etc.) that the chance was given to discover, due to the unavoidable and/or obligatory excavations, vast amounts of archaeological finds which are a valuable source for the ekistics' history of the area; they remained buried, some of them for centuries, but some others only for a few decades, during the rapid changes in the land use of the area. Another interesting item that was revealed during these preparatory excavations was the structure and form of ancient roads, still present until the 19th century (Korres, 2008).

The work done in the Kaupert maps is therefore invaluable, since many of the ancient buildings and structures depicted on the maps have since been lost, removed or are not possible to visit anymore, due to the voracious expansion of inhabited areas, especially after the mid-20th century, but also due to the construction of a new airport in the Mesogeia plain recently. In this respect, the great value of the maps is that the old road infrastructure (practically intact till the 19th century) as well as many antiquities that cannot be traced nowadays, due to the anarchic/ chaotic changes in the area, can be located. Thus the Kaupert maps can be used as a rich source of archaeological information, in a possible future recompilation and digital documentation of cultural heritage. Even more, the way this archaeological information is displayed, from the cartographic point of view, is still a model for a future archaeological map of the country.

The value of this remarkable cartographic work of the Kaupert maps can nowadays open new perspectives and acquire added value through the digital possibilities offered by Information Technologies. However, the very few attempts towards this direction that have been made so far are rather sporadic, focusing on specific and partial points of interest, such as archaeology or implementation of some GIS functionality (see e.g. URL1, Dasaklis et al. 2012, resp.). In any case there hasn't been so far a cartographically oriented perspective from the digital point of view for the Kaupert maps.

In our work we attempt to establish a digital cartographic approach which is first of all concerned with the treatment, elaboration and evaluation of the maps' geometric infrastructure and content. Our approach originates from the cartographic point of view, as opposed to the "users' approach", which might be interested in partial aspects useful for certain thematic areas only. The proper cartographic treatment, as attempted here, is a prerequisite for all consequent data processing and for the efficient use of the information present on the maps by interested scholars from various fields.

Based on the above, the themes considered in an initial step and presented in the following are related to the study of the geometric infrastructure of the maps and the monitoring of land use changes (focusing on urban and vegetation patterns).

4. Studying the geometric infrastructure and preparing the comparative analysis of geodata through time

In order to study the different geometric and thematic components of the "Karte von Attika" map sheets as well as to use it in a comparative time monitoring of basic dynamic features like urbanization or forestry combining the map content with modern maps, a process has been applied after analysing the basic geometric characteristics of the maps. For the comparative analysis, two map depictions of Attica, the 1:50000 map series of the Hellenic Military Geographical Service (1960-1970), as well as the online orthophotomaps provided through a WMS service (2009) by the Hellenic Cadastre Service were selected. The main issue here is to transform all these maps to the same geometric framework in a digital way, so that their comparison becomes possible and accurate (*Figure 2*). The basic step here is to detect first of all, the geometric features of the old maps in order to introduce the map into digital environment and to transform it to a comparable cartographic product.

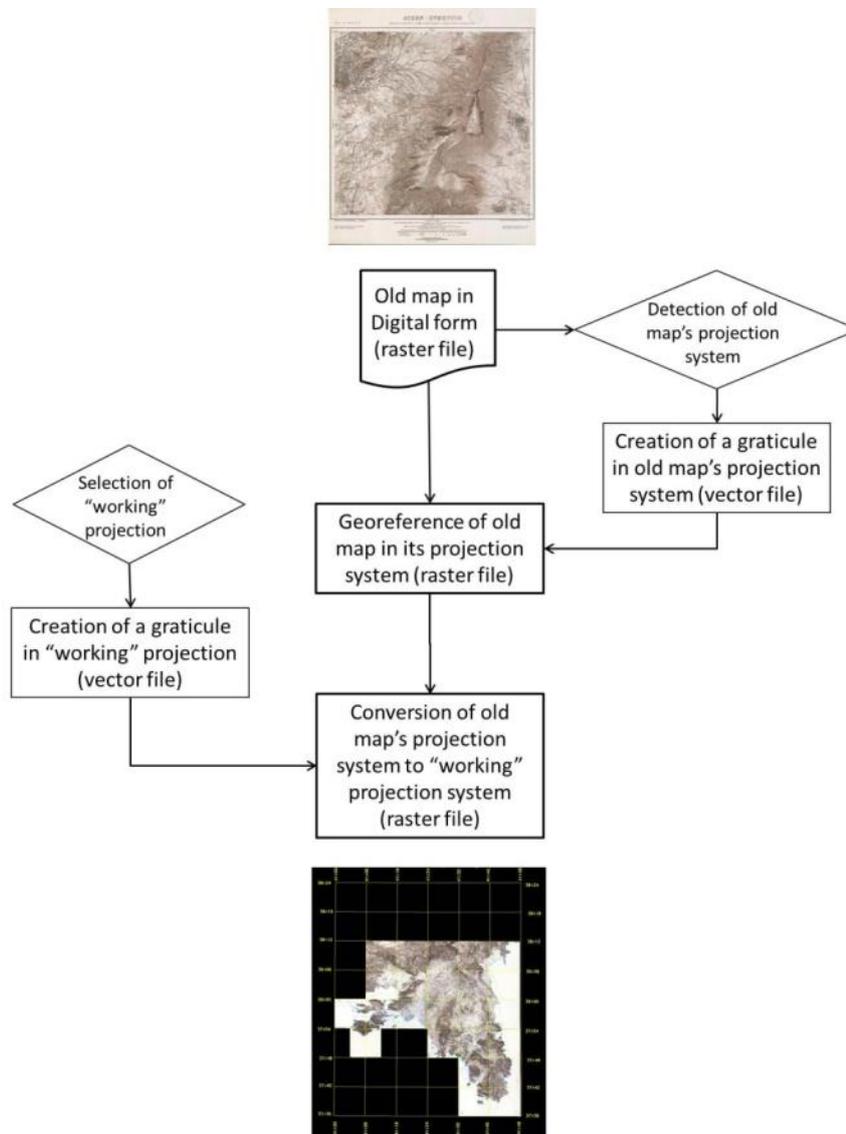


Figure 2. The procedure of giving digital cartographic nature to an old map.

4.1 Detecting of old maps projection system parameters

The *Karte von Attika* map series obey the projective properties of the family of the *polyhedral* or *trapezomorphic* projections. According to this projection system, each map-sheet of 1:100.000 or 1:200.000 constitutes a proper projection reference system (*Figure 3*).

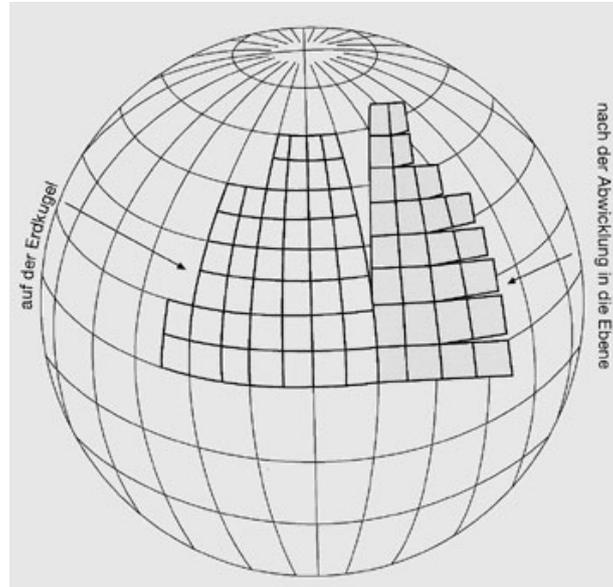


Figure 3. Prussian polyhedral projection's main concept.

We faced this family of projections some years ago during a research project on the *Generalkartem*-series 1:200.000 covering Northern Greece. Since the origin of polyhedral projection is the sinusoidal one, the Sanson-Flamsteed projection applied on the Bessel ellipsoid is selected from the digital library of projections to be our approach in order to georeference the maps, to mosaic them and to allow them to be compared and evaluated.

Before applying any digital procedure, every information given for the old maps must be considered and evaluated. Every map sheet of Atlas is 8' in longitude x 6' in latitude and in scale 1:25000 (*Figures 1, 4*).



Figure 4. Map sheet of Athens-Piraeus in scale 1:25000.

J.A. Kaupert in "Atlas von Athen" describes analytically the whole topographic procedure and among other details gives the coordinates of the Athens observatory as:

$$\varphi_A = 37^\circ 58' 20.00'' \text{ and}$$

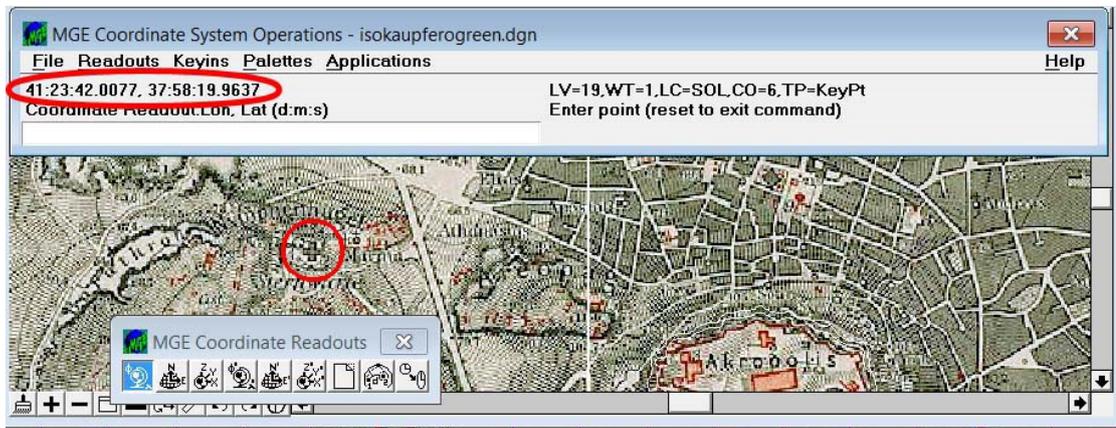
$$\lambda_A = 41^\circ 23' 42.00'' \text{ with zero meridian that of Ferro Island (usually } \lambda_F = 17^\circ 39' 46.2'')$$

which means $\lambda_A = 23^\circ 53' 56''$ from Greenwich on Bessel (*Figure 5*). This longitude value is different from the actual $\lambda_A = 23^\circ 42' 58.8''$ and leads us to assume a new value for the Ferro meridian which must be $\lambda_F = 17^\circ 40' 44.00''$, a fact actually proven by the digital process (*Figure 6*). The grid of the Sanson projection was released and the first map sheet of Athens center was georeferenced.

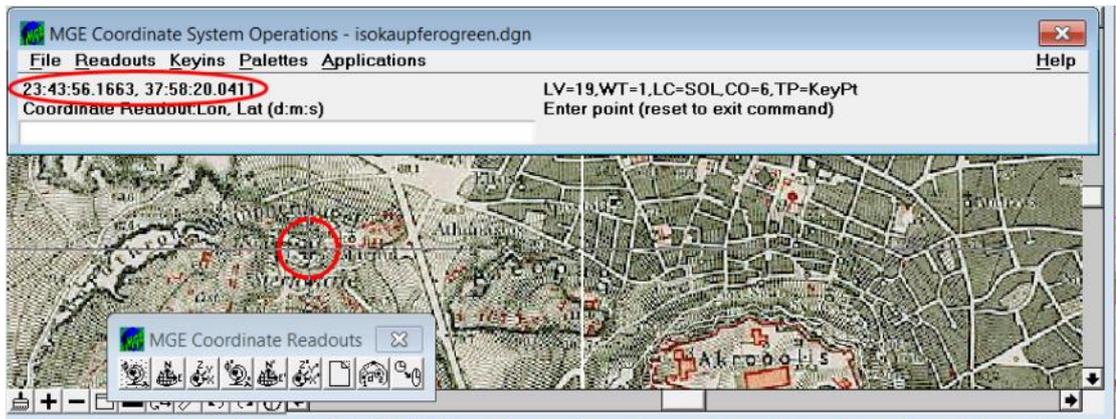
geographische Breite = $37^{\circ}58'20''$,00
 Länge = $41^{\circ}23'42''$,00 östlich v. Ferro.

No.	Ausgangspunkt a.	Gesuchter Punkt b.	Geodät. Azimuth der Richtung a b.			Geographische Breite.			Geographische Länge östlich von Paris.		
			o	f	m	o	f	m	o	f	m
1	—	Sternwarte	—	—	—	37	58	20,000	21	23	42,000
2	Sternwarte	Mire	179	54	49,0	37	57	53,379	21	23	42,051

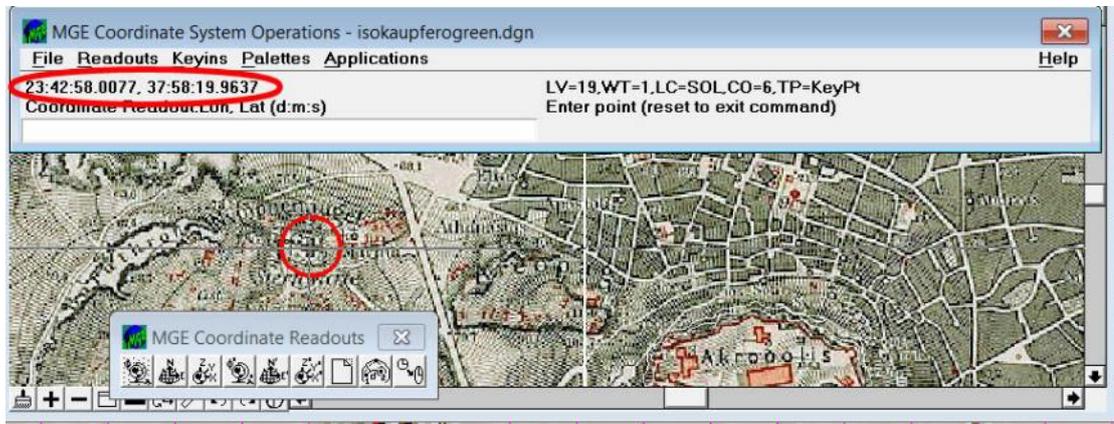
Figure 5. Details from the "Atlas von Athen" recording the coordinates of Athens Observatory from Ferro and Paris.



(a)



(b)



(c)

Figure 6. The coordinates of Athens Observatory in three different projection versions: a) with central meridian $\lambda = 41^{\circ} 24'$ where we can notice the exact coordinates given by Kaupert b) assuming $\lambda = 17^{\circ} 39' 46''$ for Ferro which gives incorrect λ, ϕ of Athens Observatory, and finally c) assuming $\lambda = 17^{\circ} 40' 44''$ which gives exactly the actual coordinates of the Athens Observatory on Bessel.

4.2. Georeferencing and transforming into common cartographic framework

All map sheets were then georeferenced in the sinusoidal projection applied on the Bessel ellipsoid and considering $\lambda_F = 17^{\circ} 39' 46''$ as the Ferro Meridian and the digital "mosaic" of the whole map in 1:25000 scale was produced. The same process (*Figure 7*) was applied for the two other maps, the 1:50000 (1960-1970) and the WMS orthophotomap (2009) and all three maps were converted in a common working projection selected for the case, the Transverse Mercator projection with central meridian this of 24° long (*Figure 8*). Thus, three different but easily comparable views of Attica were produced, all in the same projection ready to offer useful information about the development of the highly populated and historically and culturally leading area of Greece (*Figure 9*). Since forestry information was depicted on other version of Hellenic Cadastre orthophotomap, the same procedure was followed for this map in order to study the forestry factor, very important for Attica, too.

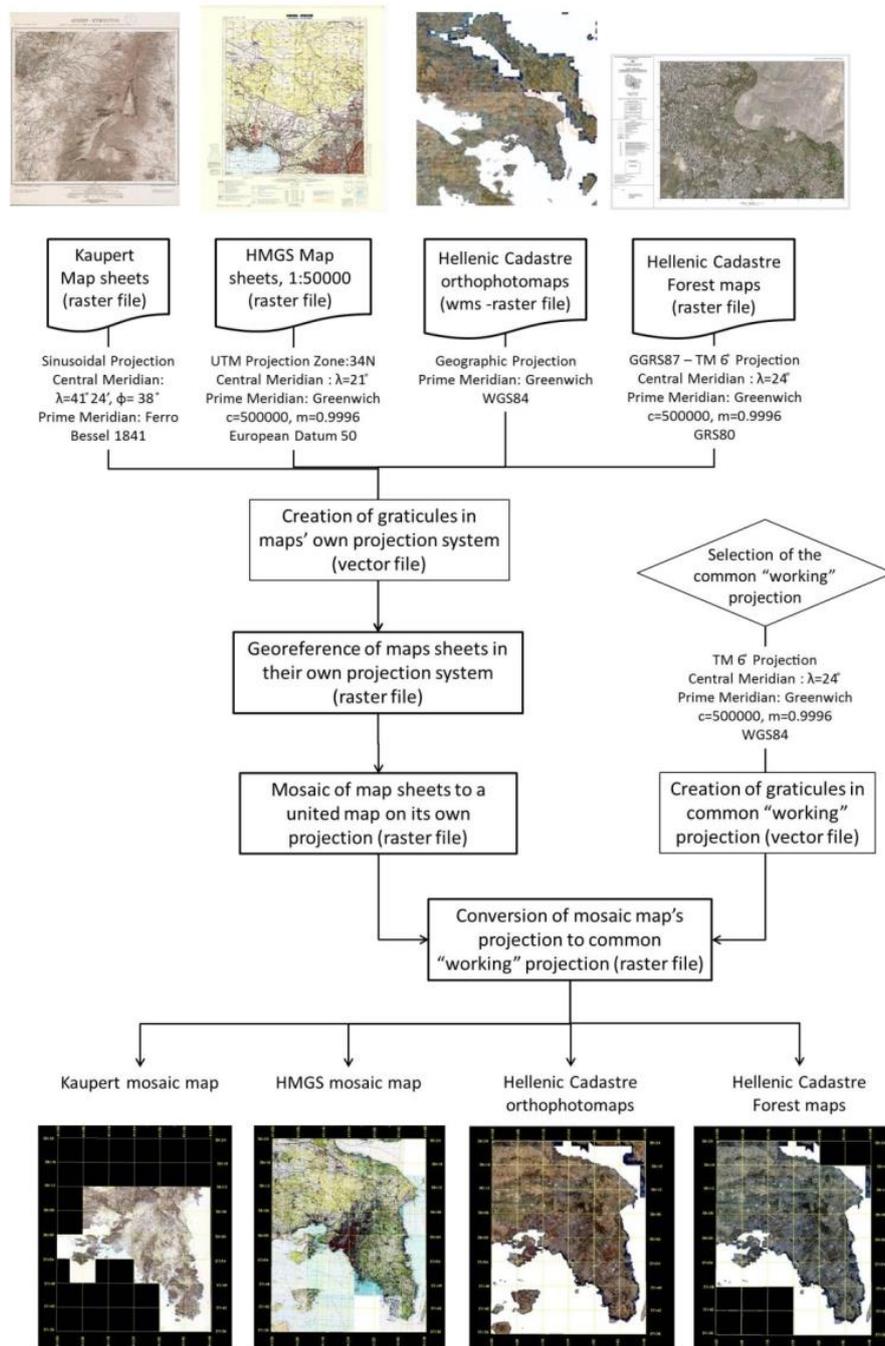


Figure 7. Introducing all maps into the same digital framework. The cartographic time layers can be used for development of town planning projects.

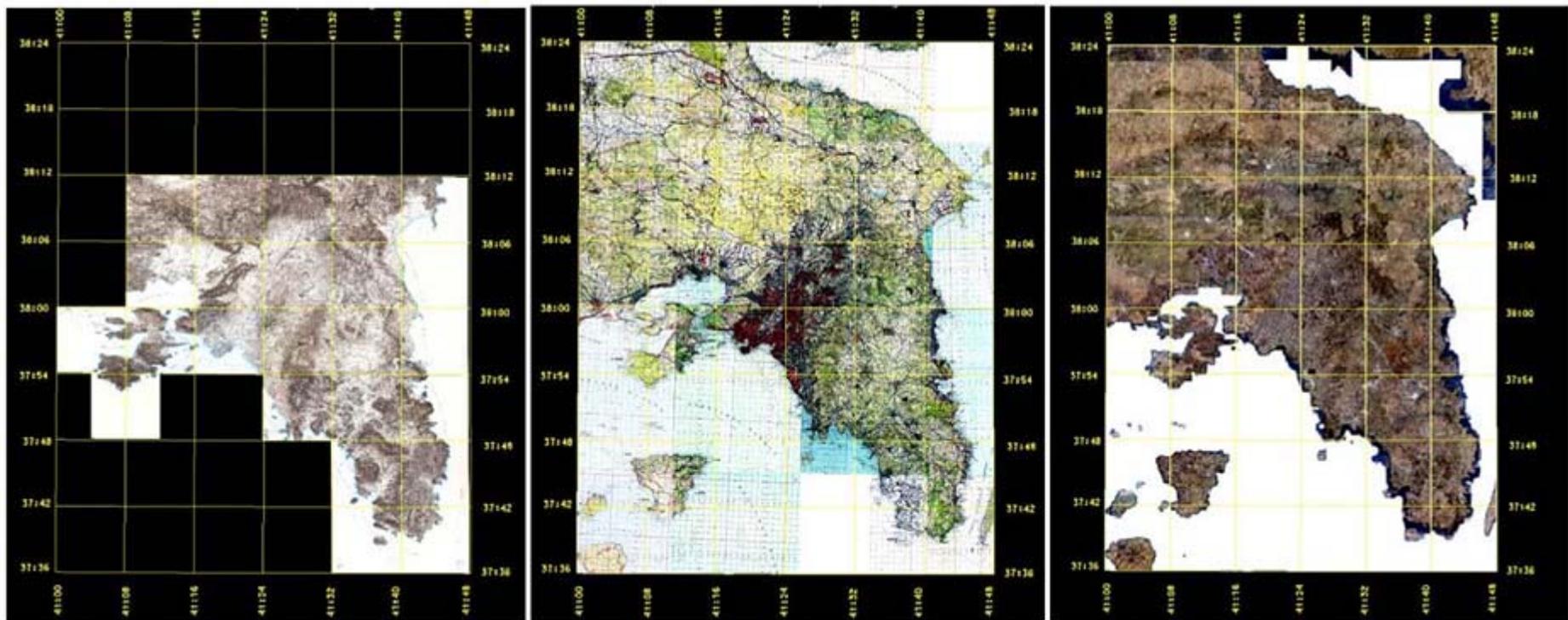


Figure 8. The three maps of Attica in their common geometric framework.

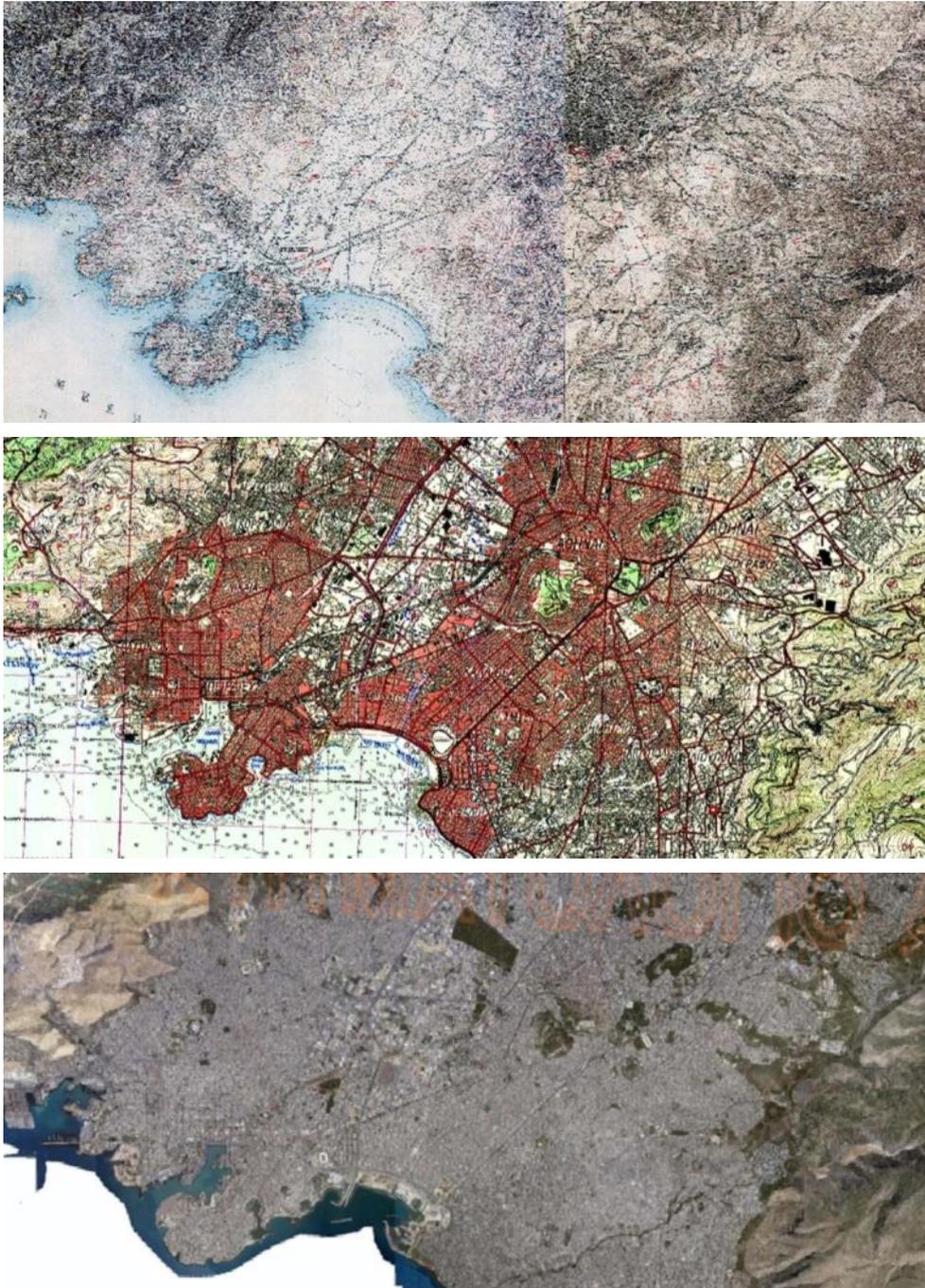


Figure 9. Athens-Piraeus through the years, on Kaupert's map (1895-1903) on HMGS in scale 1:50000 (1960-1970) and on WMS orthophotomaps by Hellenic Cadastre (2009-2010).

5. Monitoring land use changes

As a first step in our implementation the monitoring of the dramatic land use changes in the area was initiated. Urbanization, in particular, is typical in the Greater Athens Area, with various consequences, deforestation being among the most serious. The urban changes in the area during the 20th century were due to mainly two reasons: the first one was the installation of the refugees from Asia Minor following the disastrous war of 1922 and the second the internal migration from the 1950s onwards, immediately after the 2nd World War and the disastrous civil war that followed (1940-1944 and 1944-1949 respectively). Large numbers of population from the rural and mountainous mainland moved to Athens, seeking better life and work conditions; the trend continued until the late 1970s and early 1980s, contributing to a growth out of proportion and hardly sustainable. In the following Figures (10-13) some snapshots of the ongoing procedure for monitoring urban and vegetation changes in the area are shown.

In our work we settled a sound background for the digital comparison and processing of the information on Kaupert maps with other cartographic sources. As a first step the most characteristic changes in the area are being recorded and compared. The important subject of archaeological information is among the planned immediate future developments, together with other issues related to it (such as terrain and landscape features).

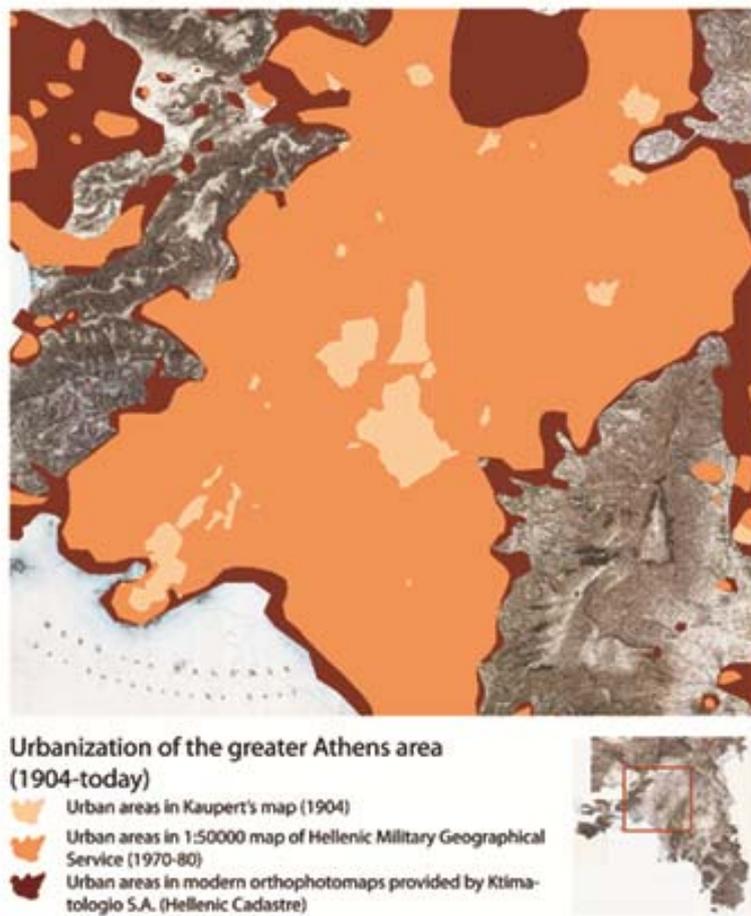
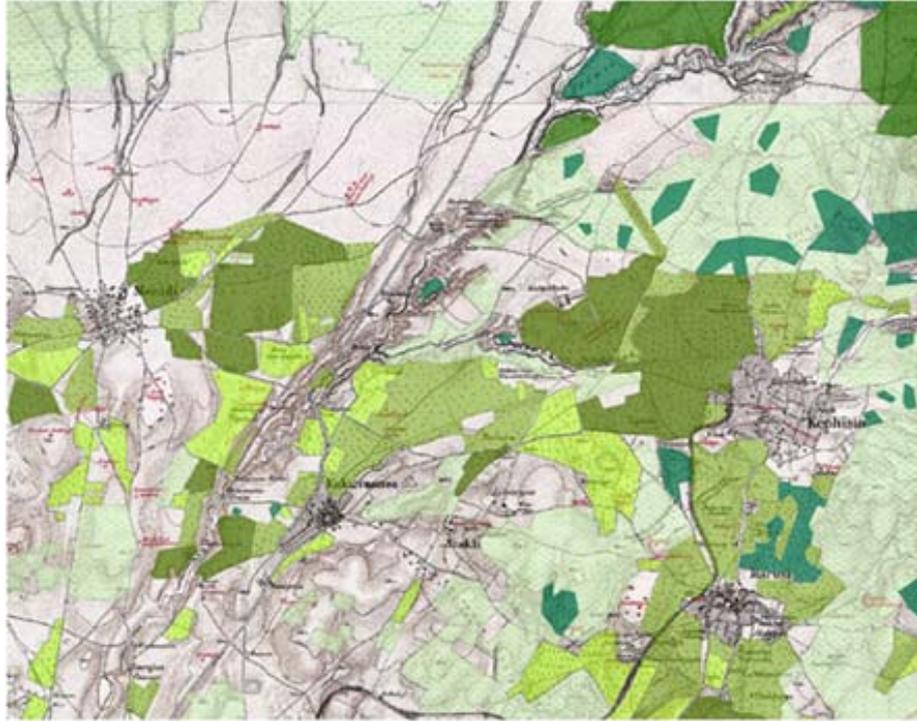


Figure 10. Below a combined image from three different time moments as compiled from the original files (in small multiples above)



Forests, vegetation and cultivation on Kaupert's map

-  Shrublands
-  Vineyards
-  Tree plantations
-  Tree plantations and vineyards
-  Coniferous, tree plantations and shrubs
-  Woodland (mainly coniferous)



Figure 11. Various types of vegetation were extracted from the Kaupert maps



An example of registered information and estimated vegetated areas in 1:5000 forest maps of Hellenic Ministry of Environment, Energy and Climate Change / Ktimatologio S.A. (Hellenic Cadastre), 2011

- Forest and forest lands in older (historical) air-photos
 - Final administrative acts & characterisation decisions
 - Groves & parks within town plans
 - Areas to be reforested or forested
 - Border of surveyed areas included in Cadastre (248/1976)
- Shrubs, vegetation
 Trees



Figure 12. In order to compare vegetation, a detailed recording of the present-day situation was carried out, based on the latest digital information available.



Estimated vegetated areas in 1:5000 forest maps of Hellenic Ministry of Environment, Energy and Climate Change / Ktimatologio S.A. (Hellenic Cadastre), 2011

Shrubs, vegetation Trees



Figure 13. Estimations concerning vegetation were generated, for the purposes of comparing with past situations.

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