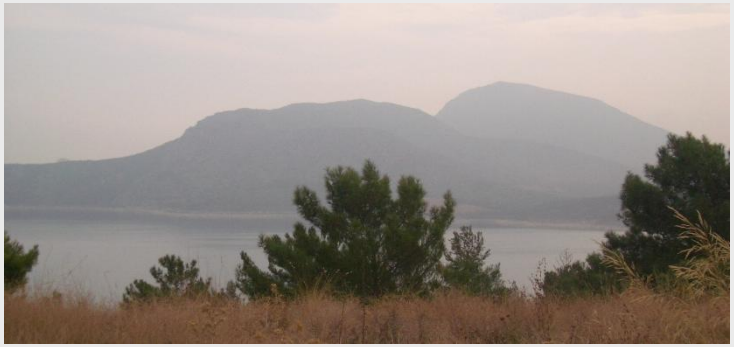
Soils in the Voiotikos Kifissos basin: their characteristics and mitigation of nitrates pollution



Theodore Karyotis

Hellenic Agricultural Organisation- General Directorate for Research

25 September, 2013

Lake Kopaida

- The lake was drained the period 1867–1931

- Land was reclaimed by building channels to drain water from the lake to the Cephissus and from there to Lake Yliki

- In total about 200 km² were reclaimed and this land was returned to the Greek government in 1952

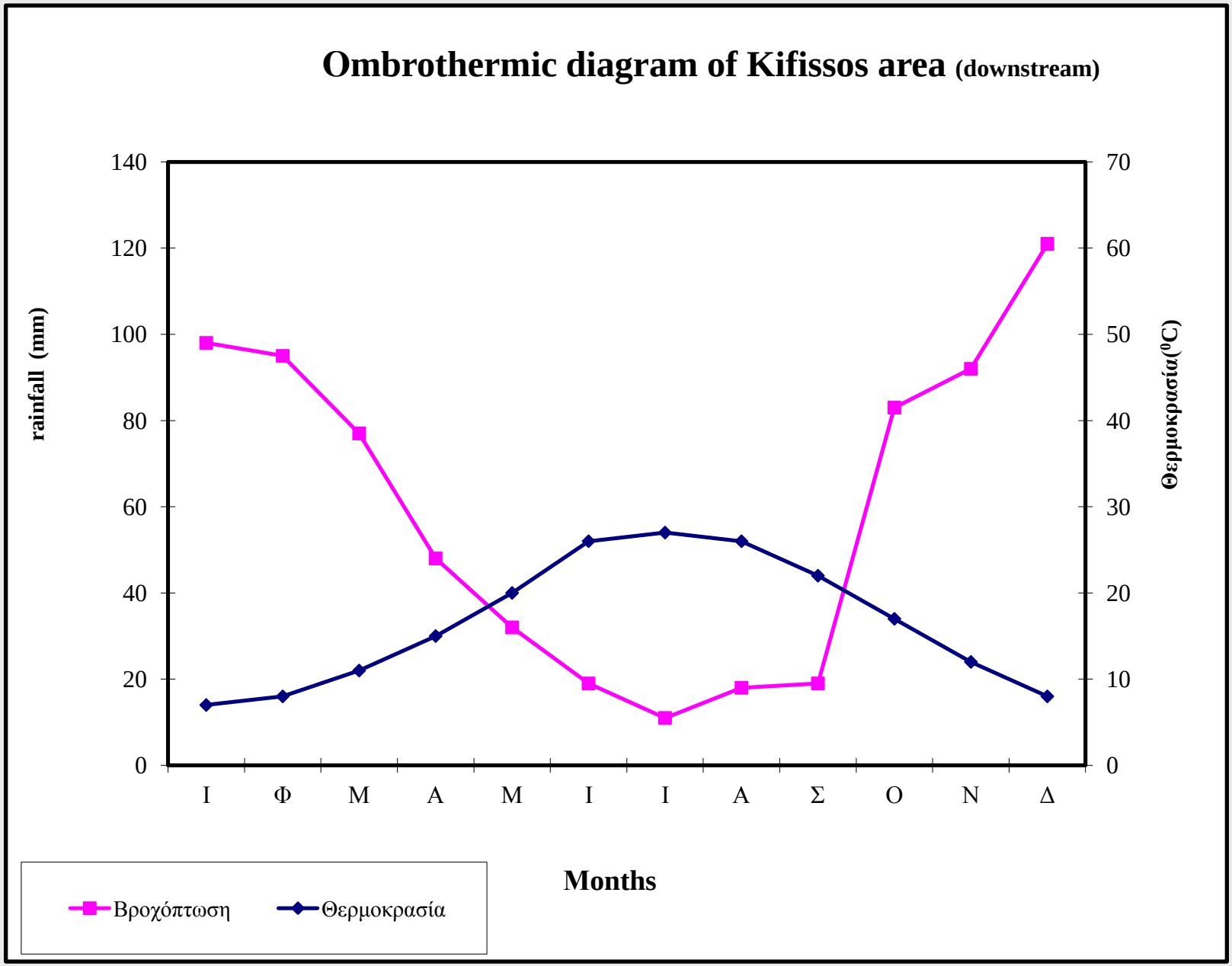
Prefecture of Voiotia

Lake Kopaida

Drainage channels

K. Rottman, La plaine de Chéronée et le lac Copais, 1835

Partial view of the drained area


Ombrothermic diagram of Kifissos area (downstream)
rainfall (mm)
Θερμοκρασία(°C)
140
120
100
80
60
40
20
0
70
60
50
40
30
20
10
0
I
Φ
M
A
M
I
I
A
Σ
O
N
Δ
Months
Βροχόπτωση
Θερμοκρασία

Soils in the pilot area of EcoPEST

Typical clay soil in the Kopais plain

Cotton is one of the main crops

Main soil orders and sub orders in the Voiotikos Kifissos basin

ENTISOLS

Orthents

- Shallow and deep soils, in slopes, good drainage
- Texture varies (SL, C), presence of $CaCO_3$

Aquents

- Insufficient drainage
- Soil texture loamy, clay loamy or clayey, presence of $CaCO_3$

VERTISOLS

Xererts

- VERTIC characteristics (cracks)
- SCL, C texture, presence of $CaCO_3$
- Deep soils, moderate or good drainage

INCEPTISOLS

Ochrepts

- Cambic horizon
- moderate or good drainage
- deep soils, soil texture varies, slope less than 4%

ALFISOLS

Xeralfs

-*Acidic soils, presence of argillic horizons*
- *d*eep soils, soil texture clay loam to clay, various slopes

Main soil mapping units orders in the EcoPEST area

$$A\frac{1*12*}{A0\ 2}Efx$$

$$A\frac{112}{A02}Efx$$

$$B\frac{214*}{A03}Efx$$

$$B\frac{334*}{A02}Ixh$$

$$B\frac{334}{A02}Ixc$$

$$B/C\frac{334}{A02}Ixh$$

$$B/C\frac{334}{A02}Ixc$$

$$C\frac{334}{A02}Ixc$$

$$C\frac{334}{A02}Ixc$$

$$C\frac{334}{A02}Ixh$$

$$C\frac{435}{A02}Ixh$$

$$C\frac{435}{A02}Ixc$$

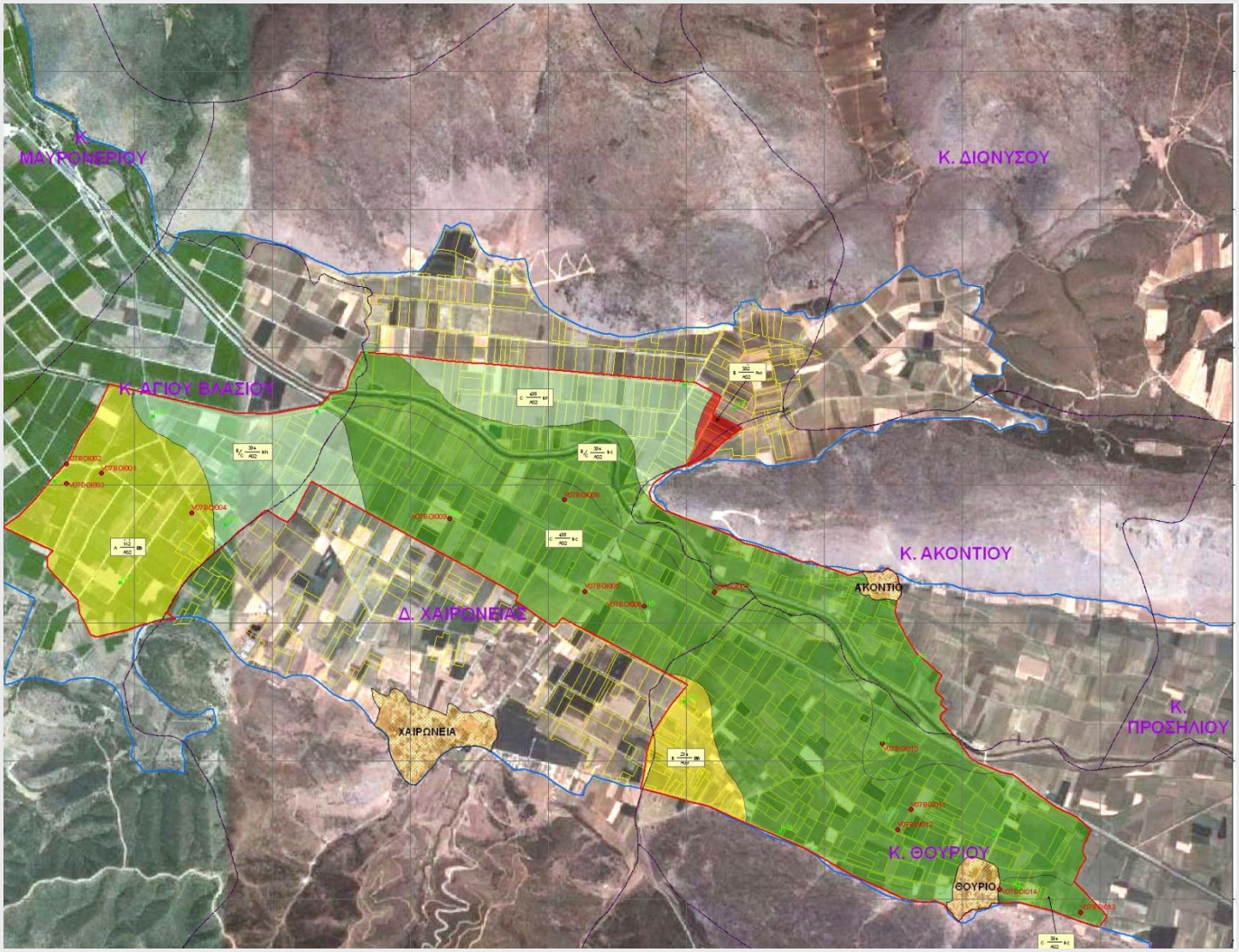
$$C\frac{435}{A02}Ixc$$

$$C\frac{435}{A02}Ixh$$

$$C\frac{435}{A02}Ixc$$

$$B\frac{33\ 2*}{A02}Axr$$

Soil map of the EcoPEST Project



Soil properties of surface horizons in the EcoPEST area

Profiles	pH	OC %	C/N	CEC cmol/kg	$CaCO_3$ %	P mg/kg
1	7,9	1,59	13,3	26,6	8,4	15
2	7,9	1,44	14,4	24,4	7	16
3	8	1,09	9,9	21,1	11,9	11
4	8,3	0,56	6,2	28,5	5,28	17
5	7,91	0,59	5,9	28,6	4	13
6	7,86	1,01	9,2	26,9	7,1	17
7	8,06	0,62	7,8	20,4	3,1	9
8	7,91	1,34	11,2	32,4	9,2	18
9	7,71	0,9	10	24,8	4,84	43
10	7,5	0,58	7,3	25,1	1,76	5
11	7,75	0,85	9,4	16,3	2,2	9
12	7,94	0,66	9,4	14	4,9	23
13	7,9	0,83	8,3	23,3	2,8	0
14	7,77	0,72	8	31,4	2,6	10
15	7,9	0,68	13,6	23,9	14,5	17
16	7,3	0,43	4,8		2,2	0,7

Soil properties of subsurface horizons

Profiles	pH	OC %	C/N	CEC cmol/kg	$CaCO_3$ %	P mg/kg
1	8	1,26	15,8	31,1	8,8	10
2	8	1,37	13,7	33,5	6,8	13
3	8,1	1,19	11,9	20,3	2,64	10
4	8,1	0,55	6,1	26,5	5,72	14
5	8,02	0,47	5,9	31,6	4,4	9
6	7,9	0,98	10,9	27,5	7,3	9
7	8,04	0,78	11,1	28,2	4,4	5
8	7,6	0,76	8,4	28,6	9,7	7
9	7,8	0,1	1,7	27,7	6,2	4
10	7,52	0,84	9,3	25,1	2,2	6
11	7,63	0,89	11,1	21,5	1,8	4
12	7,85	0,42	6	17,2	5,3	10
13	7,9	0,62	5,6	26,8	3,1	6
14	7,85	0,72	10,3	35,7	5,7	7
15	7,8	0,7	10	24,5	5,7	7
16	6,5	0,37	4,1			4

Nitrogen mineralization dynamics (t=30 weeks)

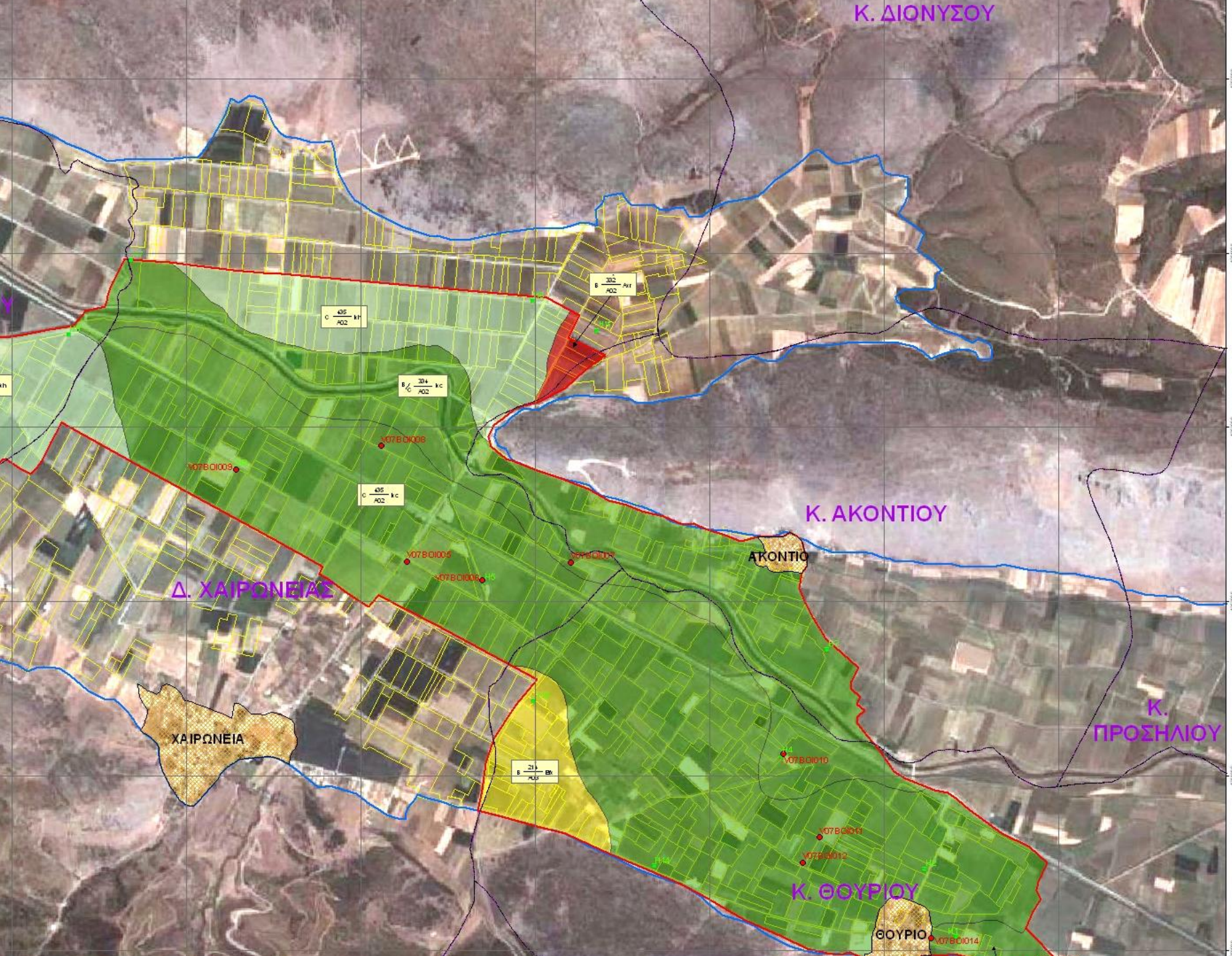
Profiles	$N_{t35}{}^0C$	$N_{t25}{}^0C$	$N_{t15}{}^0C$	N_0	constant *k*	N_{min} 35 ^0C	N_{min} 25 ^0C	N_{min} 15 ^0C
	mg/kg					kg/ha		
P1	36.25	20.14	11.19	69.39	0.052	153	85	47
P2	39.04	21.67	12.04	80.22	0.058	164	91	51
P3	32.13	17.85	9.92	63.64	0.053	135	75	42
P4	42.77	23.76	13.20	83.91	0.053	180	100	56
P5	38.53	21.40	11.89	73.18	0.050	162	90	50
P6	48.85	27.14	15.08	95.93	0.057	190	106	59
P7	30.72	17.07	9.48	64.77	0.059	129	72	40
P8	58.06	32.26	17.92	115.71	0.054	218	121	67
P9	49.07	27.26	15.14	95.25	0.053	184	102	57
P10	48.17	26.76	14.87	91.02	0.052	188	104	58
P11	55.55	30.86	17.14	107.50	0.054	217	121	67
P12	59.42	33.01	18.34	117.34	0.054	223	124	69
P13	53.49	29.72	16.51	100.88	0.053	209	116	64
P14	57.87	32.15	17.86	104.65	0.049	226	126	70

Trace elements

Categories	Fe	Cu	Zn	Mn
	(mg/kg)			
☼ excellent	0 – 11	< 0,8	< 2,9	<14
☺ moderate	12 – 24	0.9 – 1.5	3.0 – 5.0	15 – 29
☻ risk	>25	>1,6	>5,1	>30

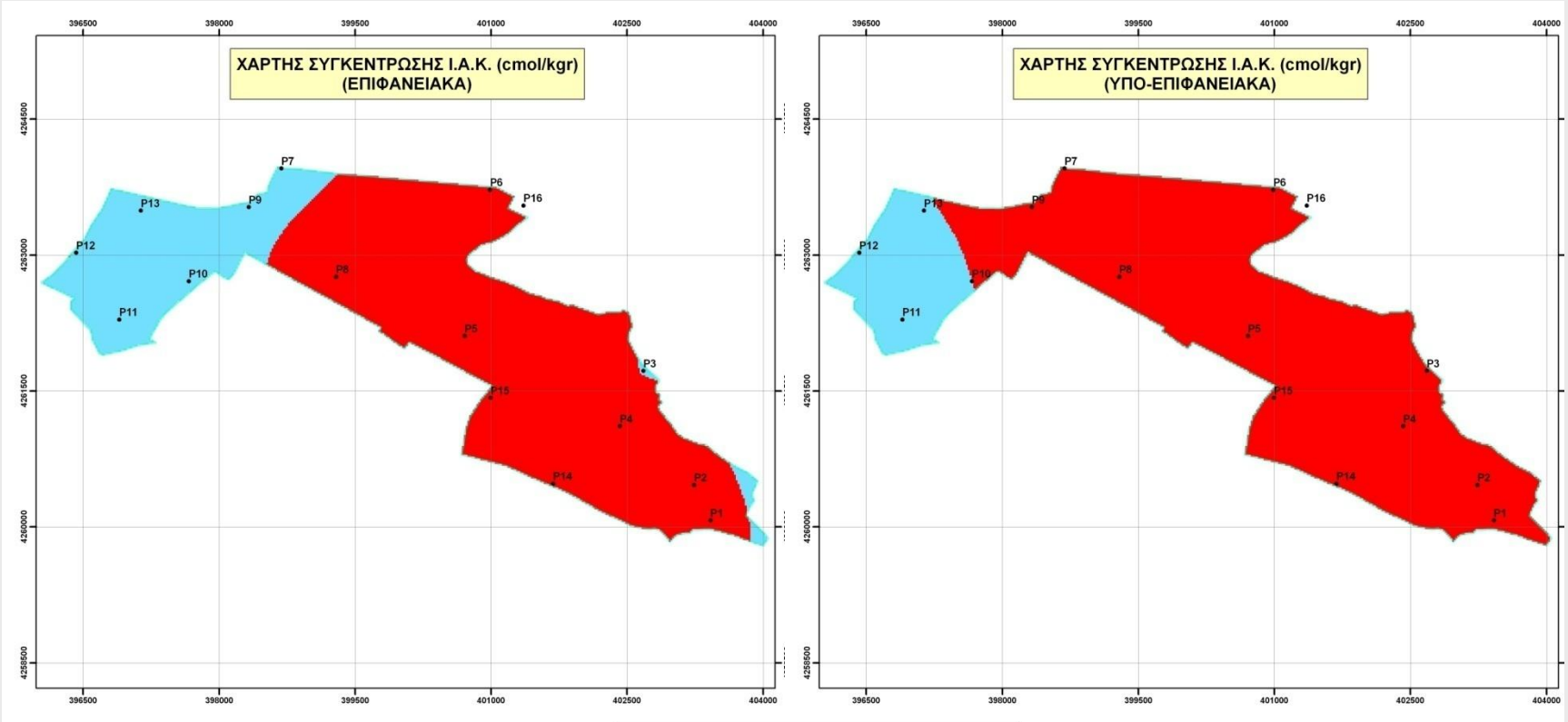
Profile	Fe	Categories	Cu	Categories	Zn	Categories	Mn	Categories
DTPA (mg/kg)								
P1	17	☺	0.90	☼	0.26	☼	20	☺
	18	☺	1.0	☺	0.50	☼	18	☺
	0.7	☼	2.90	☻	8.20	☻	8.2	☼
P2	20	☺	1.60	☺	0.35	☼	23	☺
	22	☺	1.40	☺	0.41	☼	25	☺
	13	☺	0.93	☺	1.70	☼	7	☼
P3	18	☺	1.00	☺	0.34	☼	21	☺
	18	☺	1.20	☺	0.53	☼	19	☺
	11	☼	0.70	☼	17.0	☻	7.6	☼
P4	17	☺	1.3	☺	0.35	☼	22	☺
	27	☻	1.3	☺	0.39	☼	24	☺
	25	☻	1.0	☺	1.3	☼	9.8	☼
P5	20	☺	1.2	☺	0.31	☼	19	☺
	20	☺	1.1	☺	0.77	☼	18	☺
	21	☺	0.78	☼	1.1	☼	7.1	☼
P6	16	☺	1.6	☺	0.32	☼	26	☺
	16	☺	1.5	☺	0.32	☼	22	☺
	9.6	☼	1.2	☺	1.2	☼	6.7	☼
P7	19	☺	1.2	☺	0.18	☼	19	☺
	18	☺	1.2	☺	0.3	☼	16	☺
	12	☺	0.89	☼	1.0	☼	6.6	☼

Profile	Fe	Categories	Cu	Categories	Zn	Categories	Mn	Categories
DTPA (mg/kg)								
P8	30	☻	2.4	☻	0.34	☼	23	☺
	33	☻	2.2	☻	0.52	☼	22	☺
	19	☺	1.7	☺	0.5	☼	7.2	☼
P9	38	☻	3.4	☻	0.3	☼	17	☺
	40	☻	3.1	☻	0.29	☼	18	☺
	24	☺	2.6	☻	0.99	☼	5.2	☼
P10	22	☺	1.8	☻	0.3	☼	23	☺
	22	☺	1.6	☺	0.26	☼	22	☺
	12	☺	1.2	☺	1.4	☼	6.3	☼
P11	18	☺	1.7	☻	0.24	☼	20	☺
	21	☺	1.6	☺	0.28	☼	23	☺
	14	☺	1.3	☺	2.5	☼	6.7	☼
P12	21	☺	1.9	☻	0.32	☼	20	☺
	24	☺	2.0	☻	0.87	☼	19	☺
	14	☺	1.4	☺	3.4	☺	5.4	☼
P13	21	☺	2.2	☻	0.29	☼	16	☺
	27	☻	2.0	☻	0.93	☼	17	☺
	14	☺	1.6	☺	1.6	☼	4.9	☼
P14	12	☺	3.0	☻	1.0	☼	25	☺
	13	☺	2.5	☻	1,06	☼	22	☺
	12	☺	2.0	☻	2.0	☼	8.4	☼


Κ. ΔΙΟΝΥΣΟΥ
Κ. ΑΚΟΝΤΙΟΥ
Δ. ΧΑΙΡΩΝΕΙΑΣ
ΑΚΟΝΤΙΟ
ΧΑΙΡΩΝΕΙΑ
Κ. ΠΡΟΣΗΛΙΟΥ
Κ. ΘΟΥΡΙΟΥ
ΘΟΥΡΙΟ
V07BOI008
V07BOI009
V07BOI005
V07BOI006
V07BOI007
V07BOI010
V07BOI011
V07BOI012
V07BOI014

THEMATIC MAPS OF THE EcoPEST Project

Cation exchange capacity



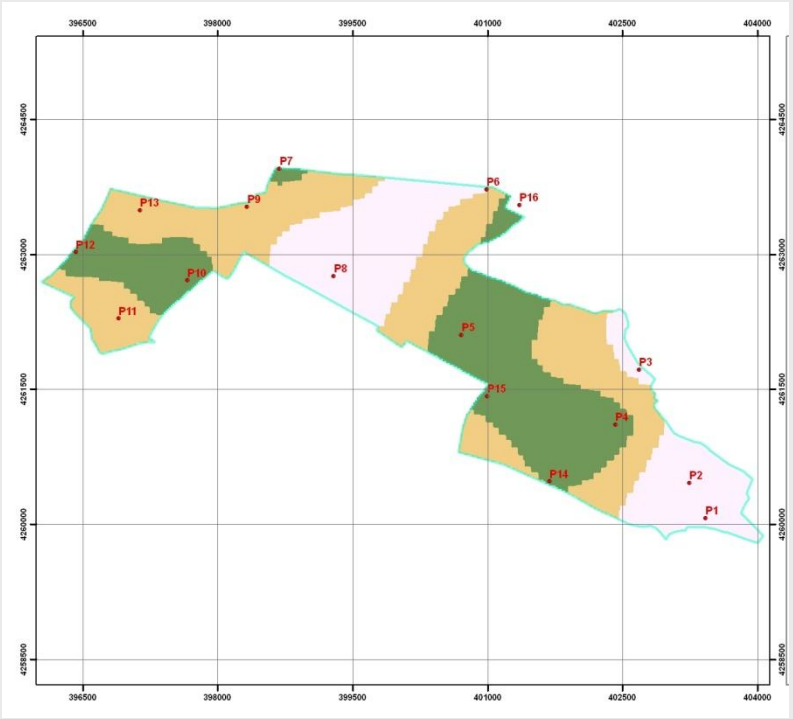
ΥΠΟΜΝΗΜ,Α

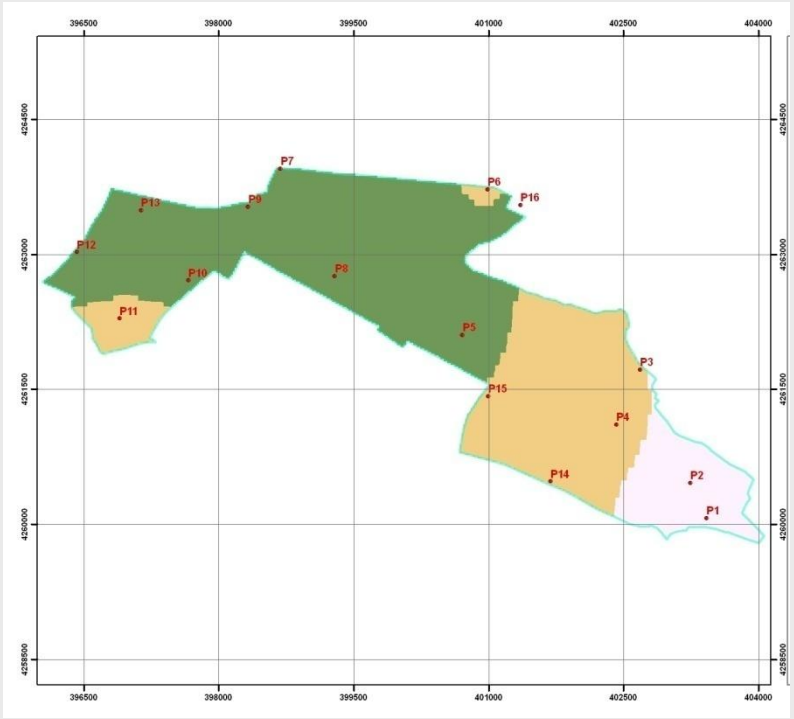
- ΘΕΣΕΙΣ ΕΔΑΦΙΚΟΥ ΠΡΟΦΙΛ
- ΠΙΛΟΤΙΚΗ ΠΕΡΙΟΧΗ

Κατηγορίες Ι.Α.Κ.
(cmol/kgr)

- Χαμηλή - Πολύ Χαμηλή: < 12
- Μέση: 13 - 25
- Υψηλή - Πολύ Υψηλή: > 26

Soil organic carbon





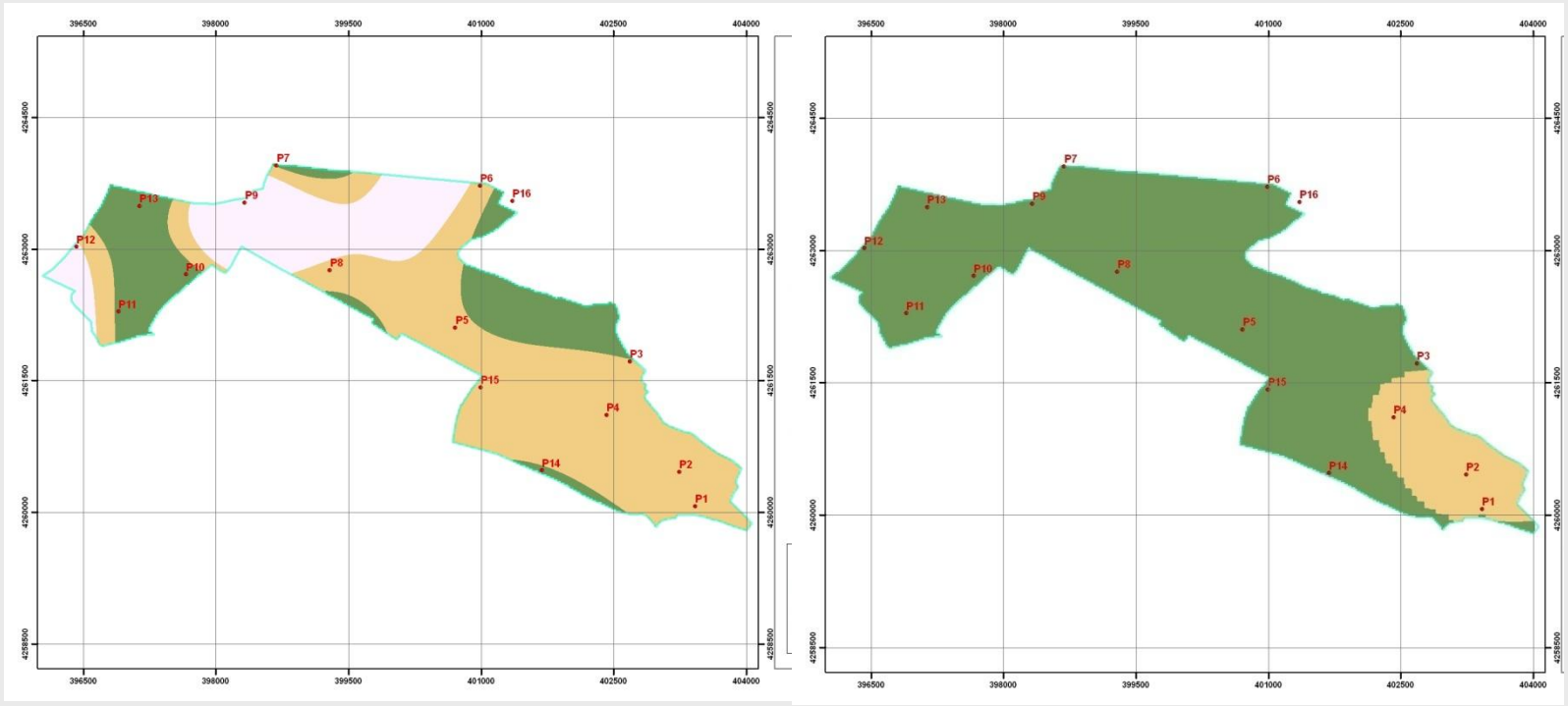
Organic Carbon (%)

0,445 - 0,696

0,697 - 0,948

0,949 - 1,576

Available phosphorus



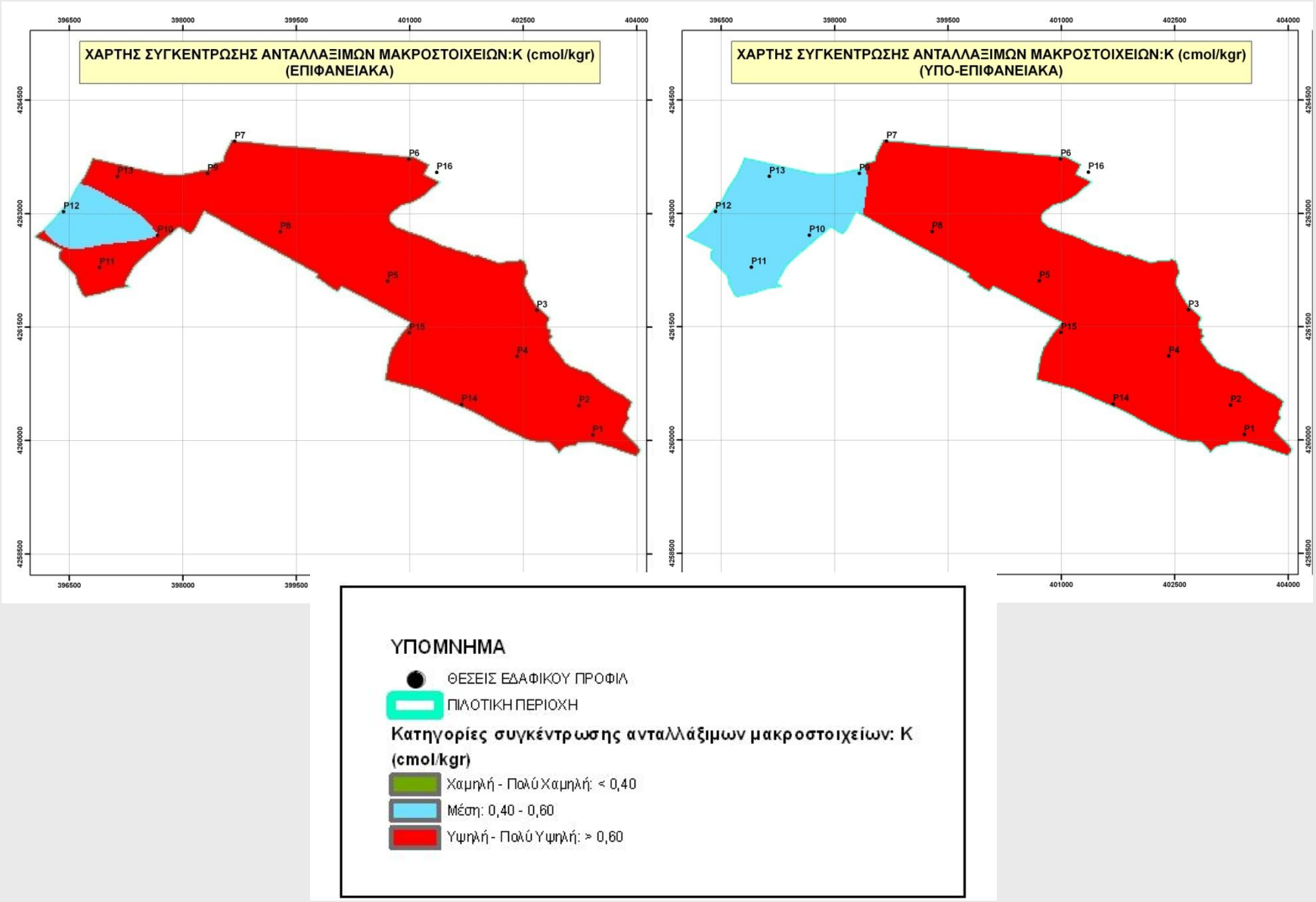
LEGEND

- Soil Profile Sites
- Pilot Area

Plant available Phosphorus [Sub-Surface] (mg/kgr)

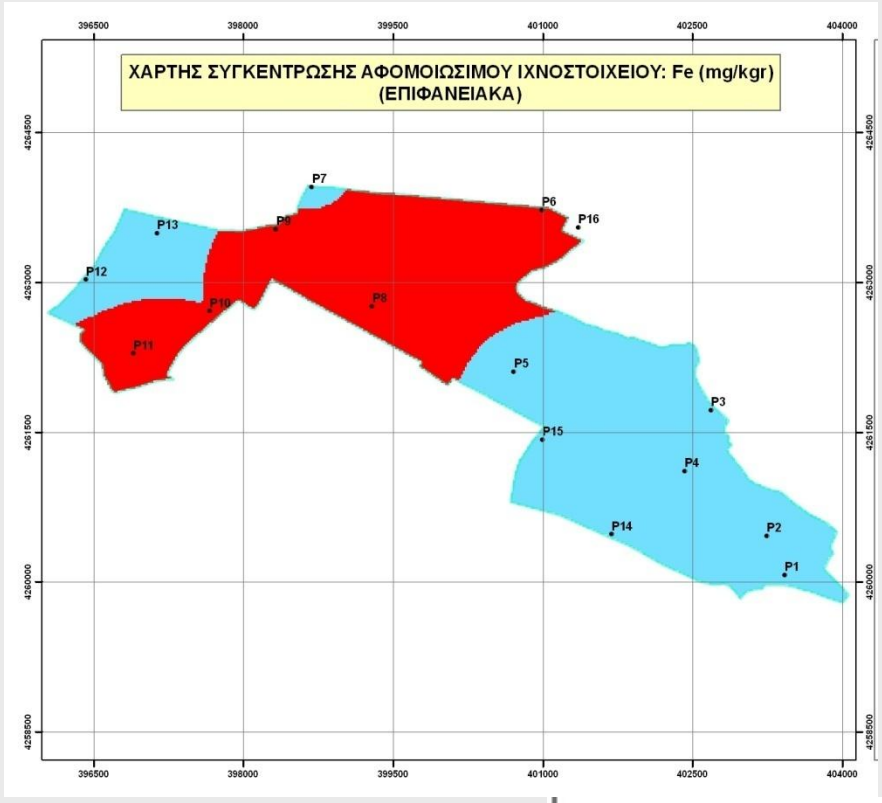
- 0 - 10,7
- 10,8 - 20,89
- 20,90 - 25,97

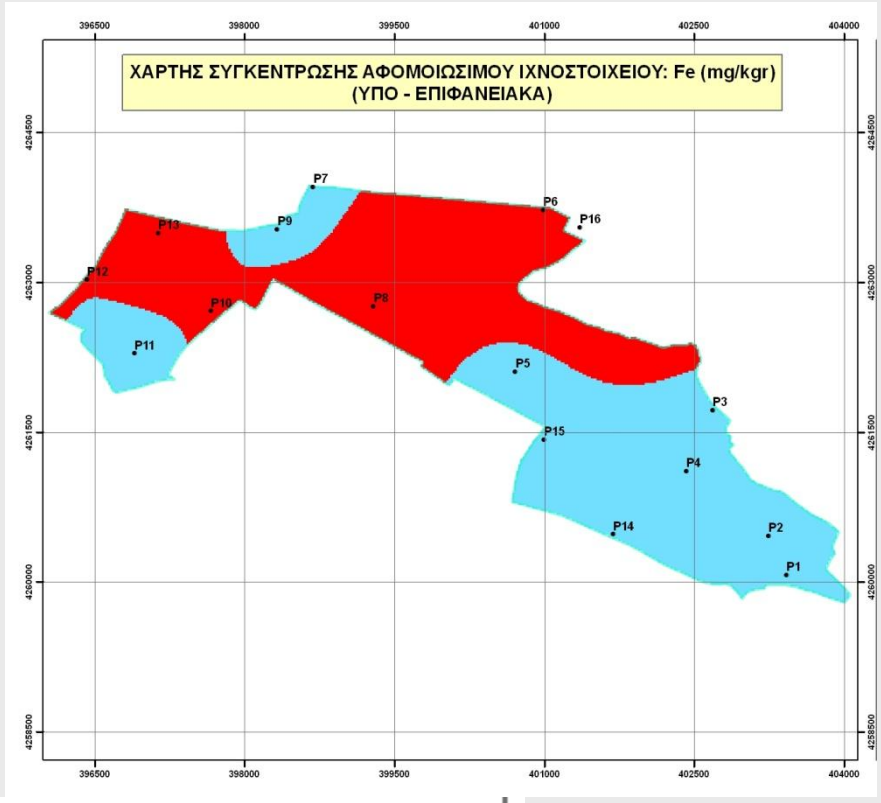
Exchangeable potassium

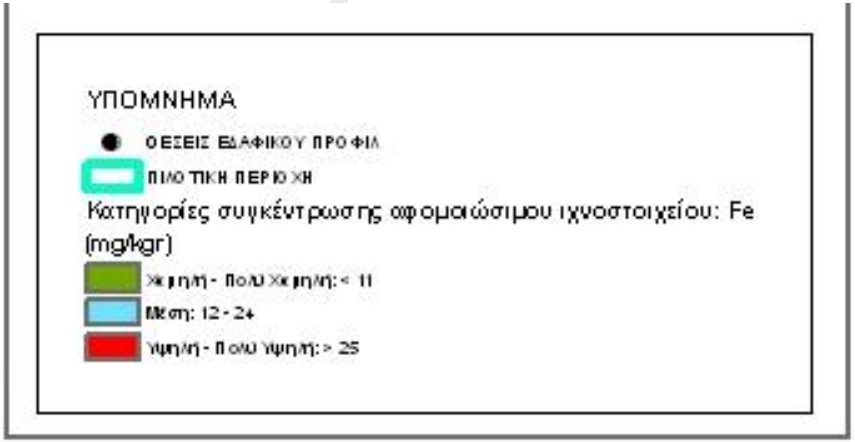


THEMATIC MAPS OF TRACE ELEMENTS

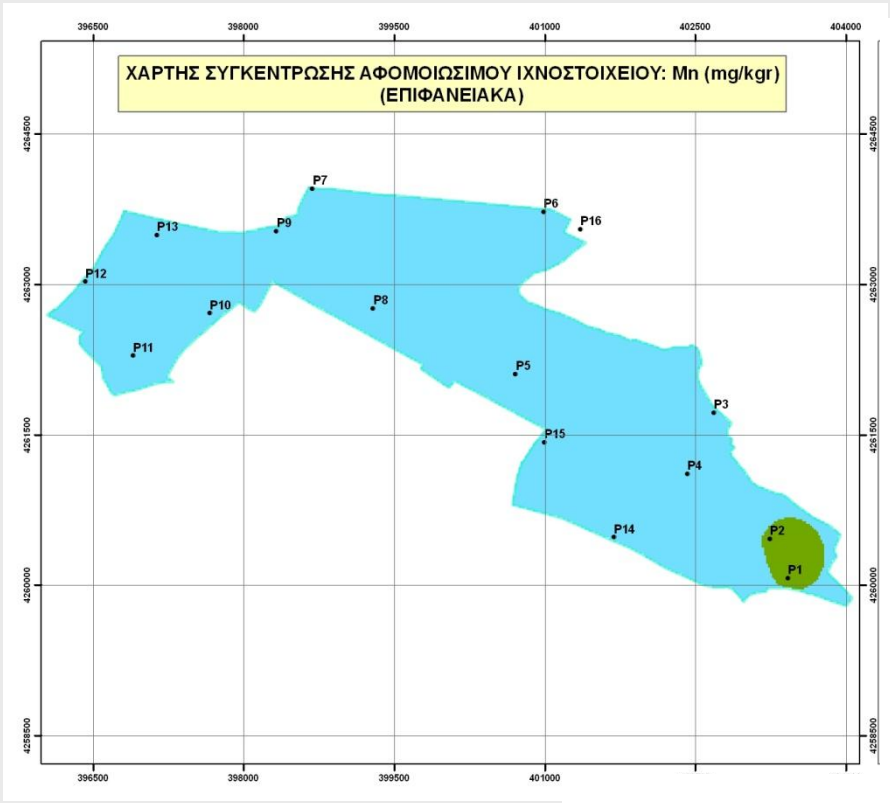
Distribution of iron

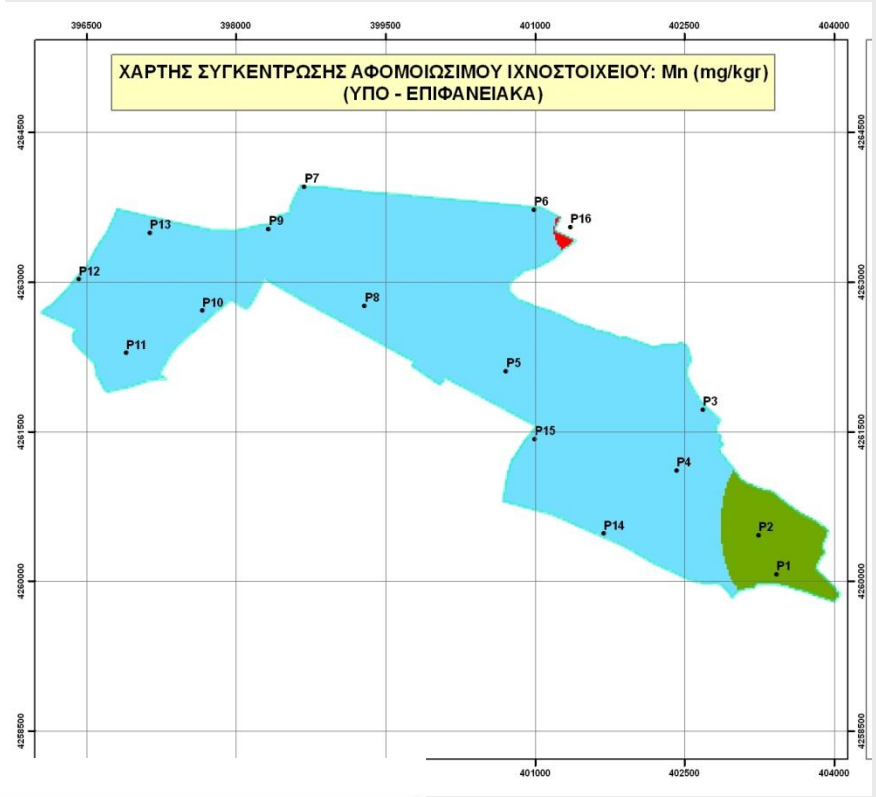


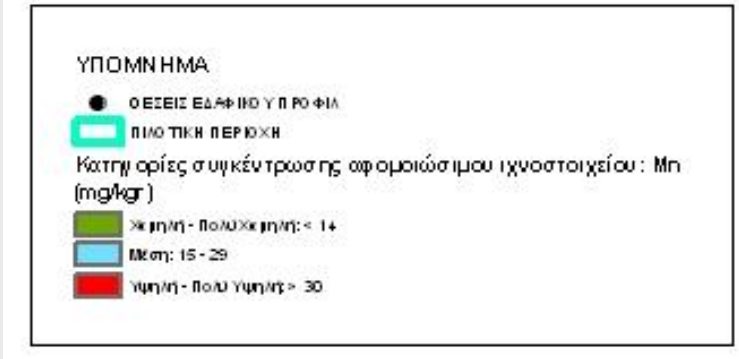




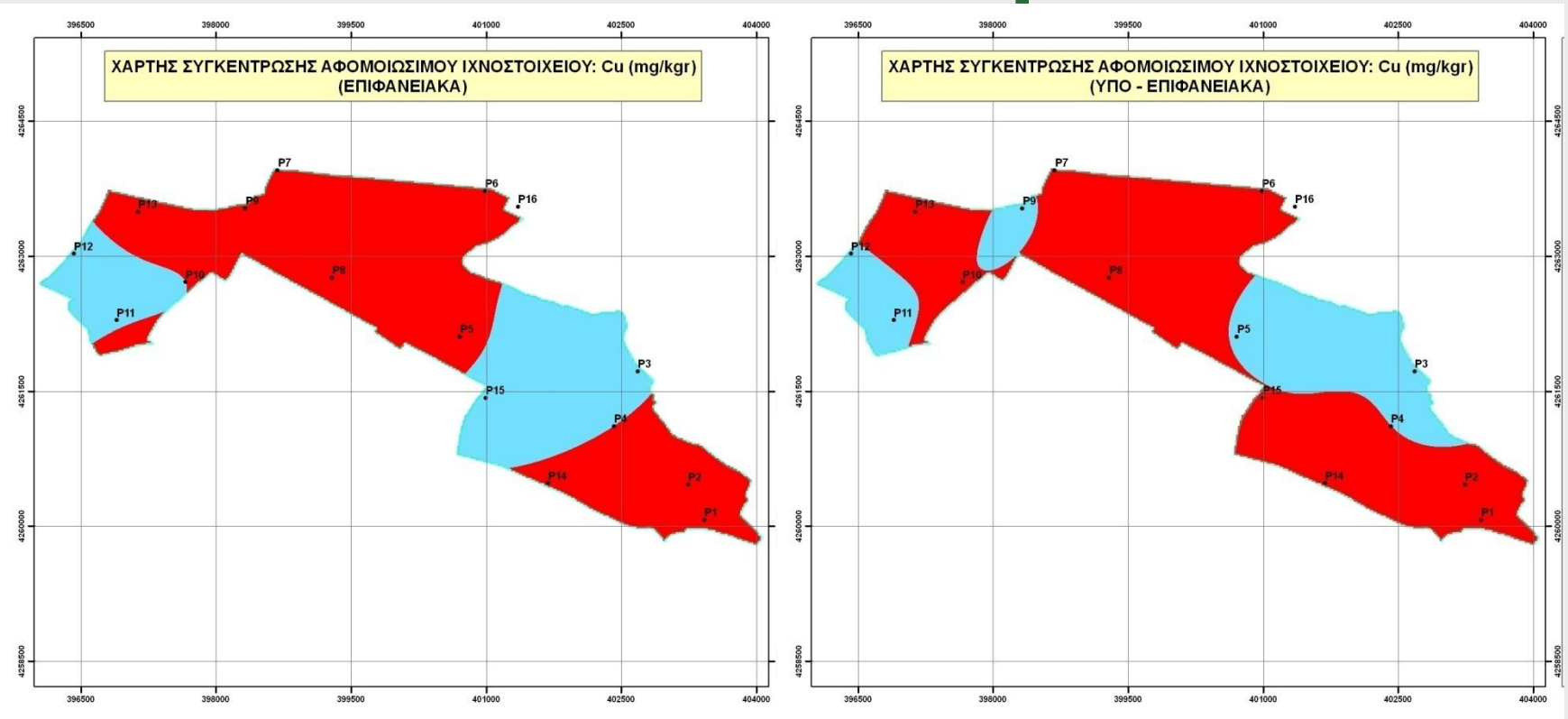
Distribution of manganese

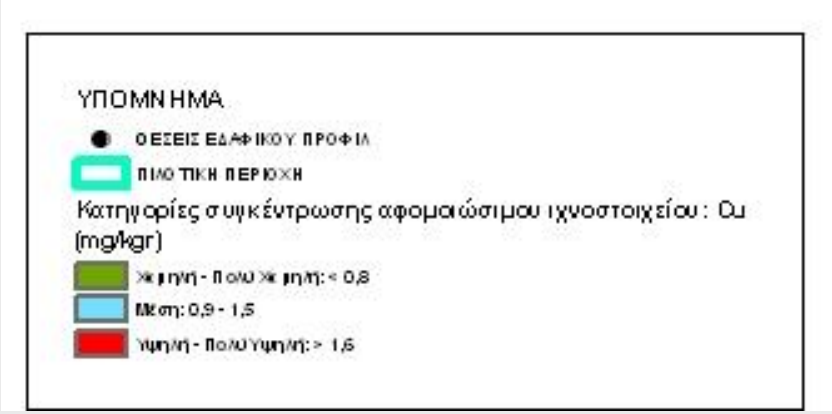




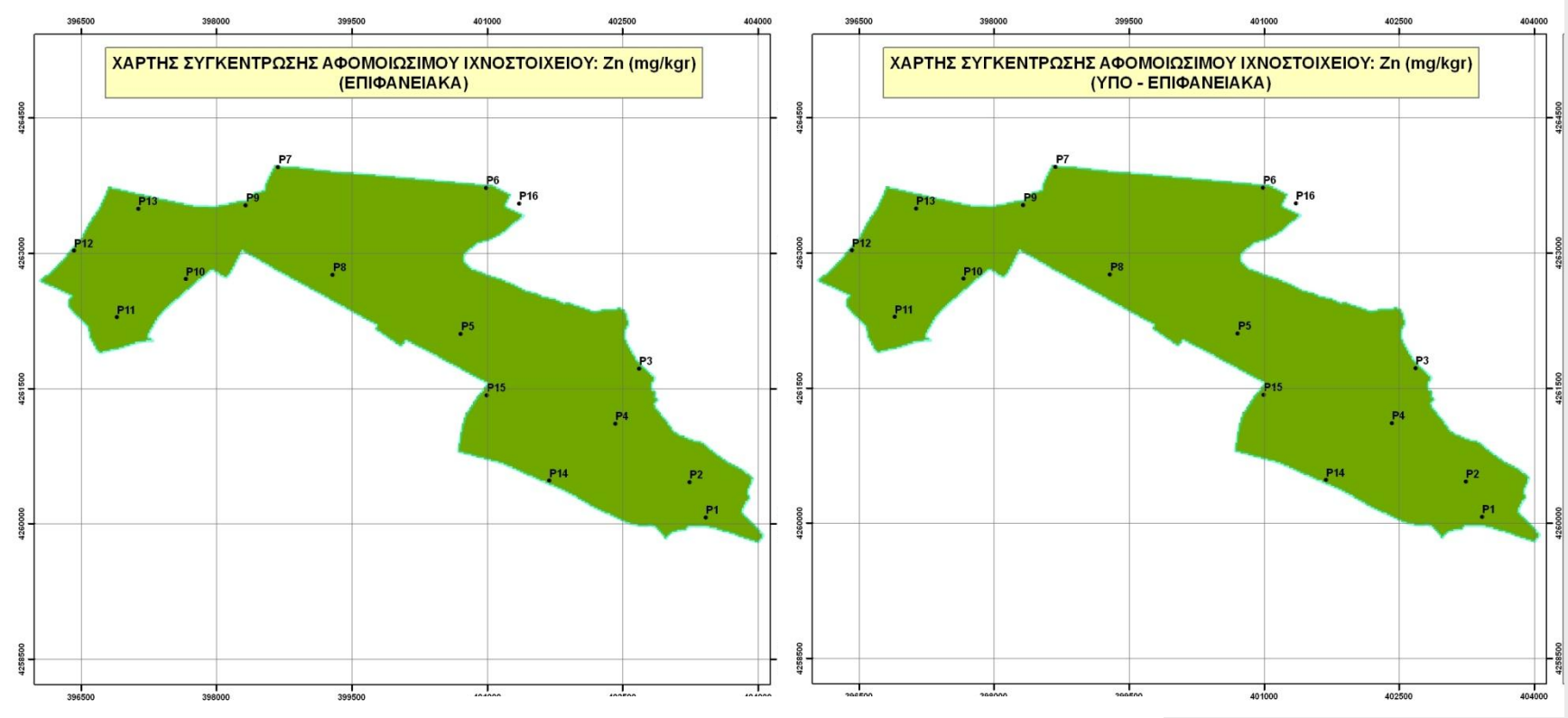


Distribution of cooper





Available zinc



ΥΠΟΜΝΗΜΑ

ΘΕΣΕΙΣ ΕΔΑΦΙΚΟΥ ΠΡΟΦΙΛ

ΠΙΛΟΤΙΚΗ ΠΕΡΙΟΧΗ

Κατηγορίες συγκέντρωσης αφομοιώσιμου ιχνοστοιχείου: Zn (mg/kgr)

Χαμηλή - Πολύ Χαμηλή: < 2,9

Μέση: 3,0 - 5,0

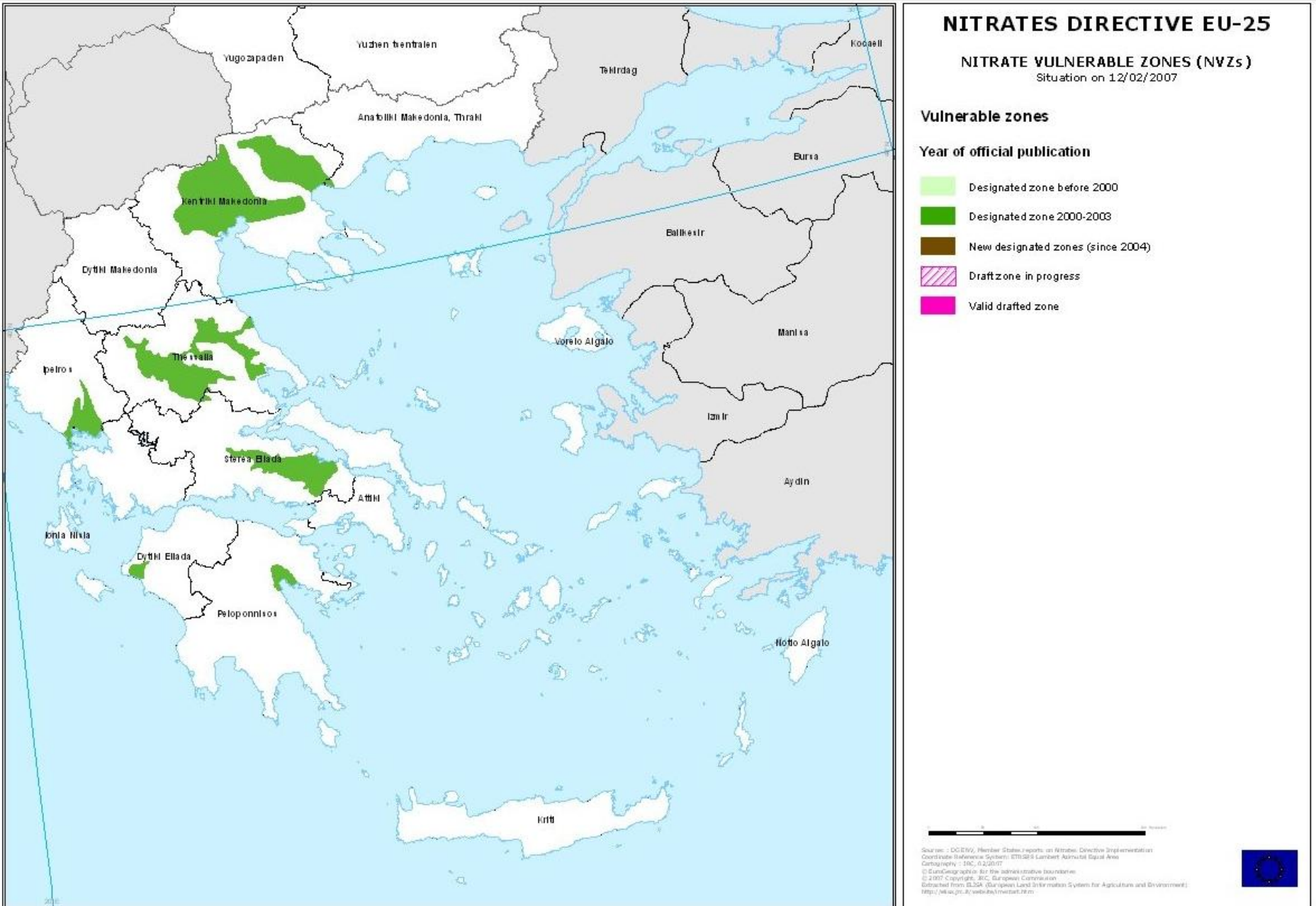
Υψηλή - Πολύ Υψηλή: > 5,1

Nitrates pollution from agriculture

Nitrates Vulnerable Zones in Greece

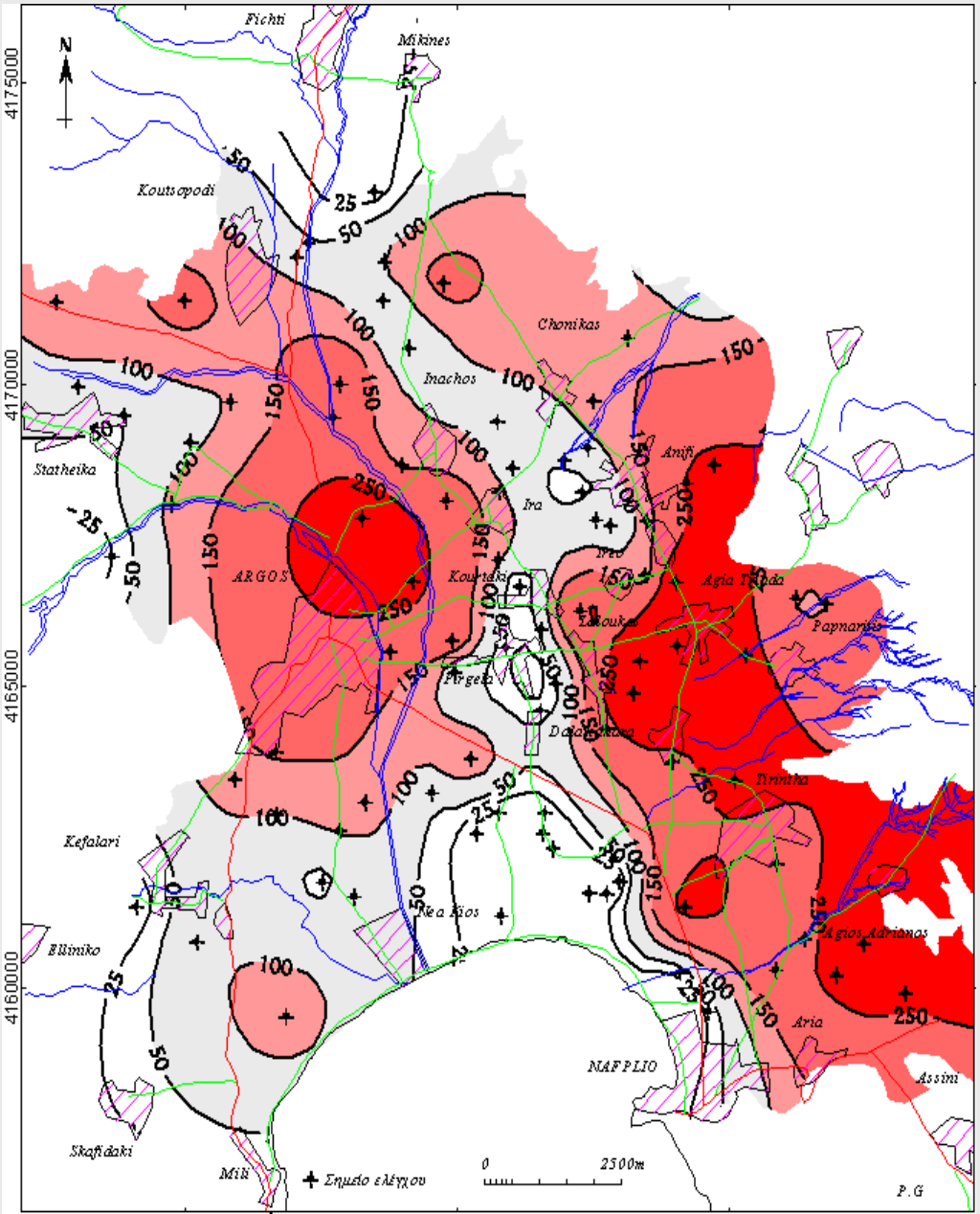
1. THESSALY
2. ARGOLIDA PLAIN
3. PART OF HLEIA, W. PELOPONNESE
4. VOIOTIA
5. ARTA, PREVEZA AND PART OF THE PREFECTURE OF IOANNINA
6. PARTS IN THE PREFECTURE OF SERRES, DRAMA AND KAVALA
7. PREFECTURE OF KILKIS AND THESSALONIKI
8. LOWLANDS IN THE PREFECTURES OF PELLA AND HMATHIA

Preliminary map of the NVZs in Greece

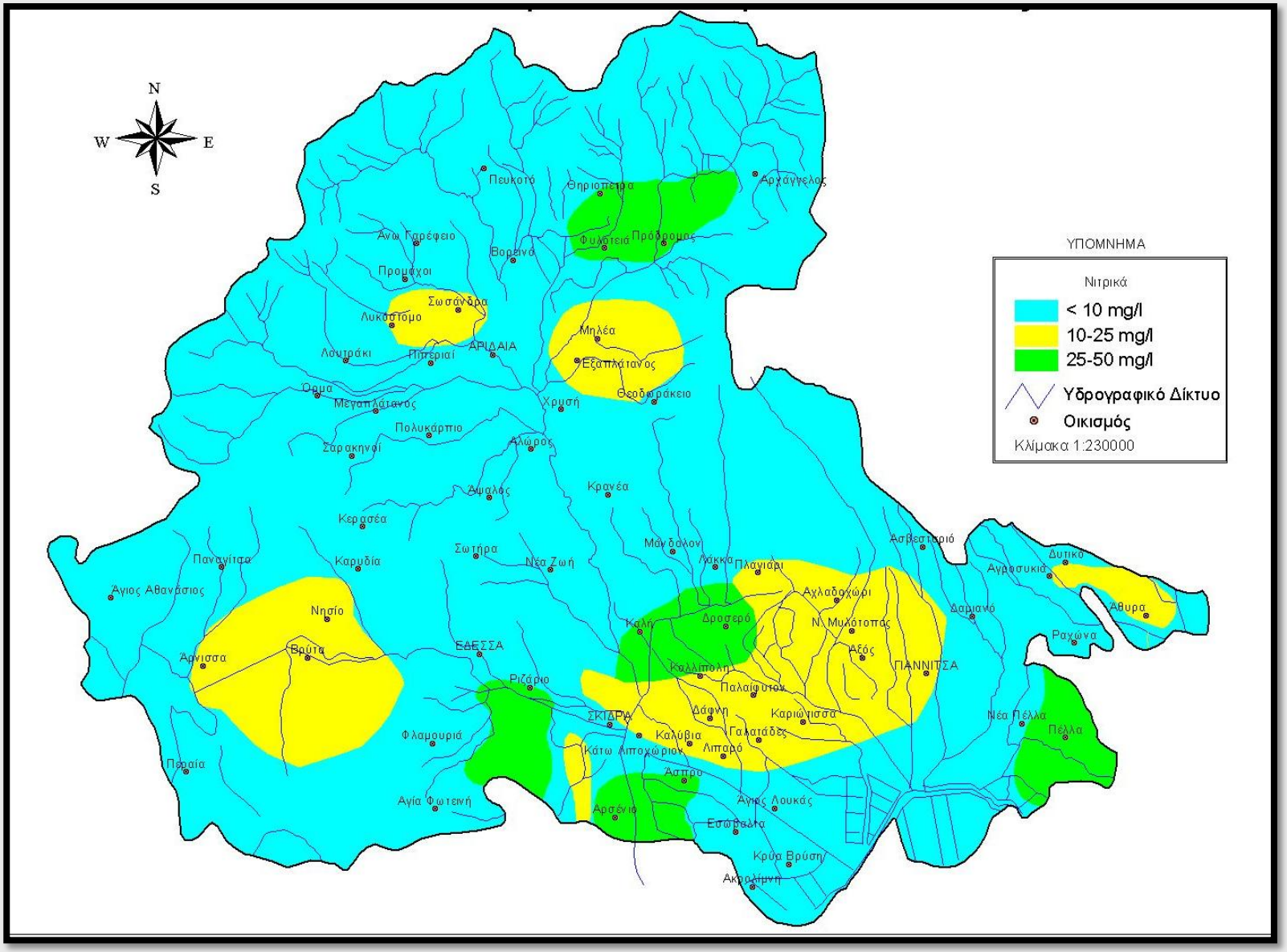


Nitrates in groundwater of S. Greece (Argolida)

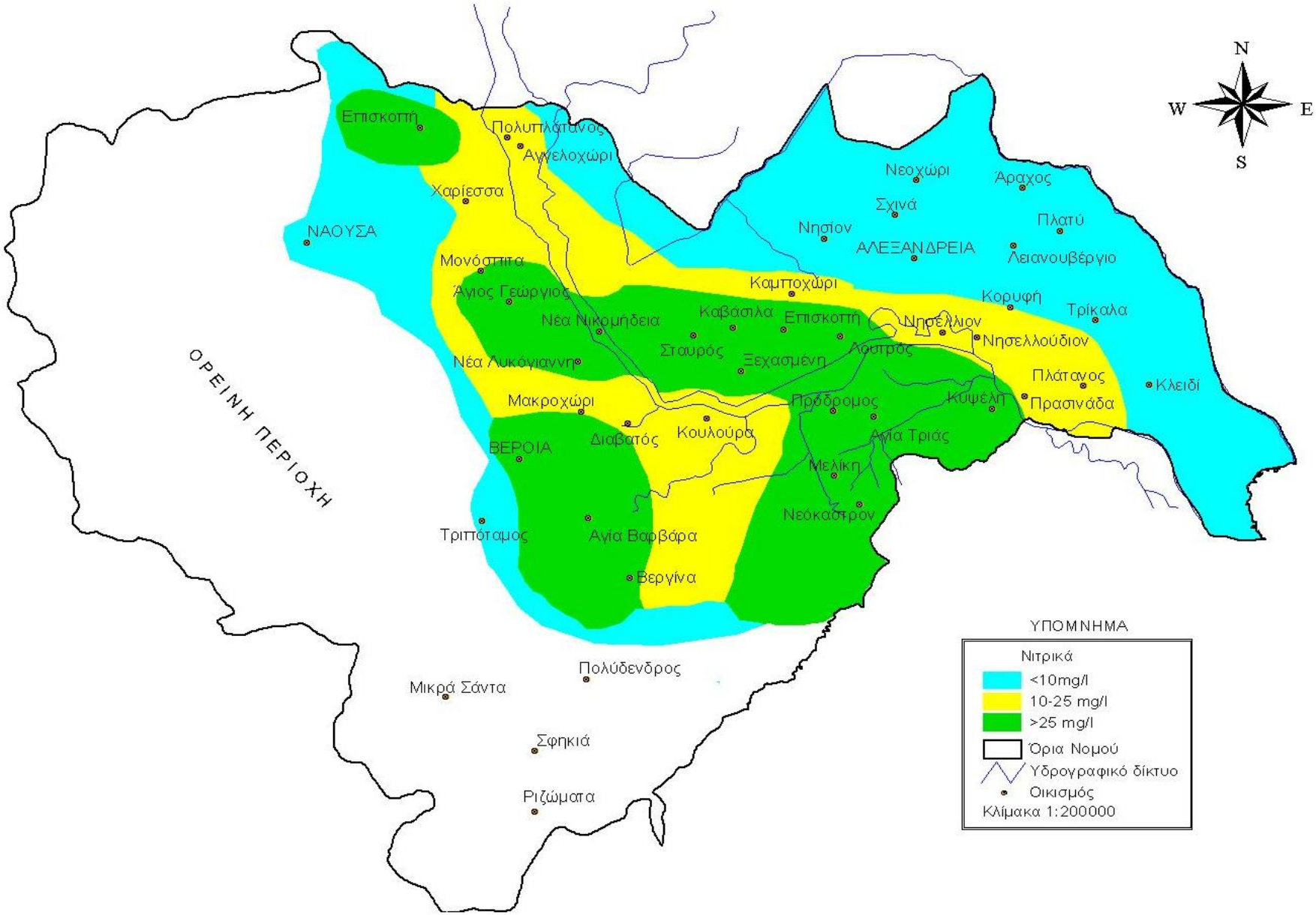
(Giannoulopoulos,1999)



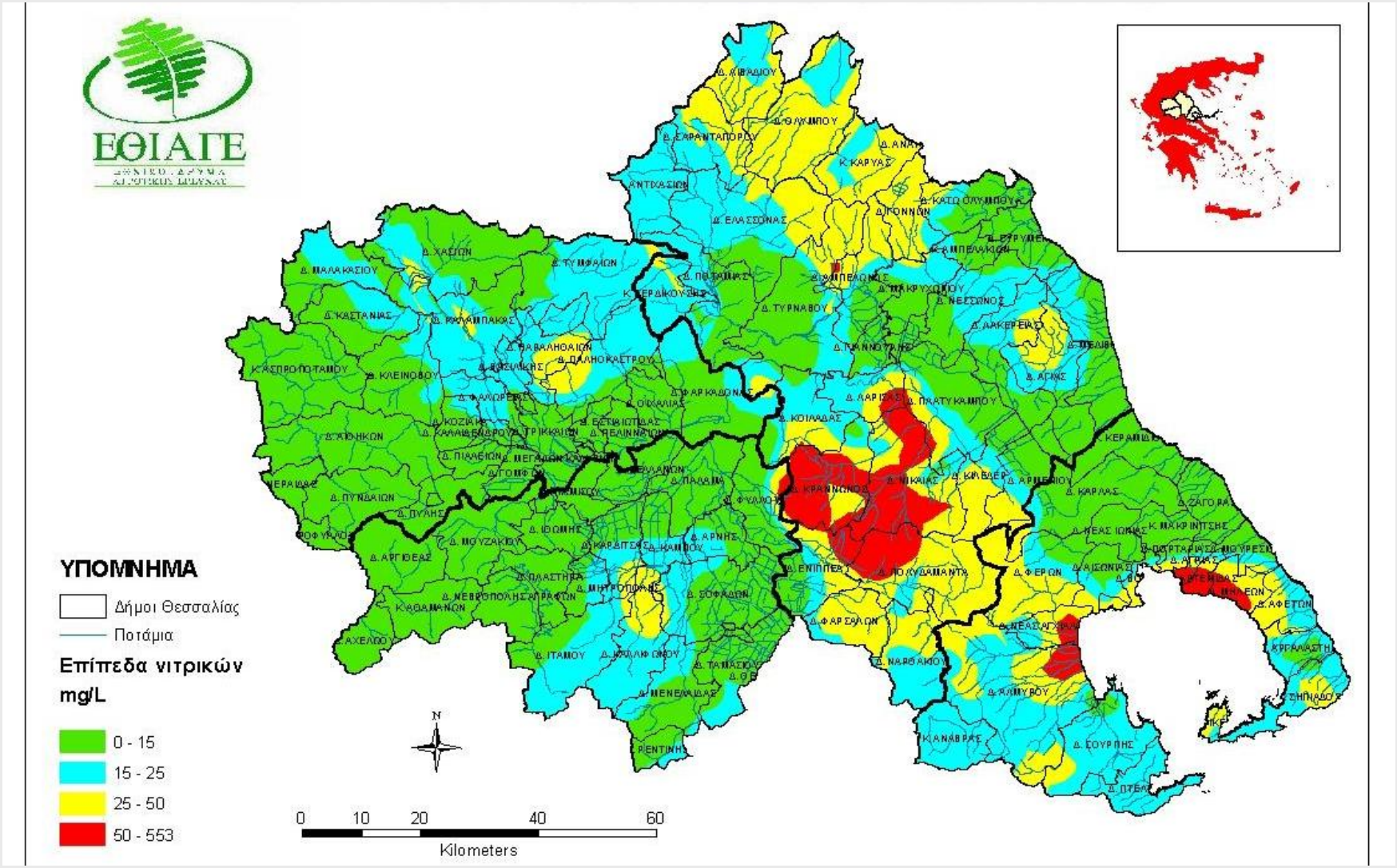
Nitrates in the waters of the Prefecture of Pella



Nitrates content in N. Greece (Imathia)

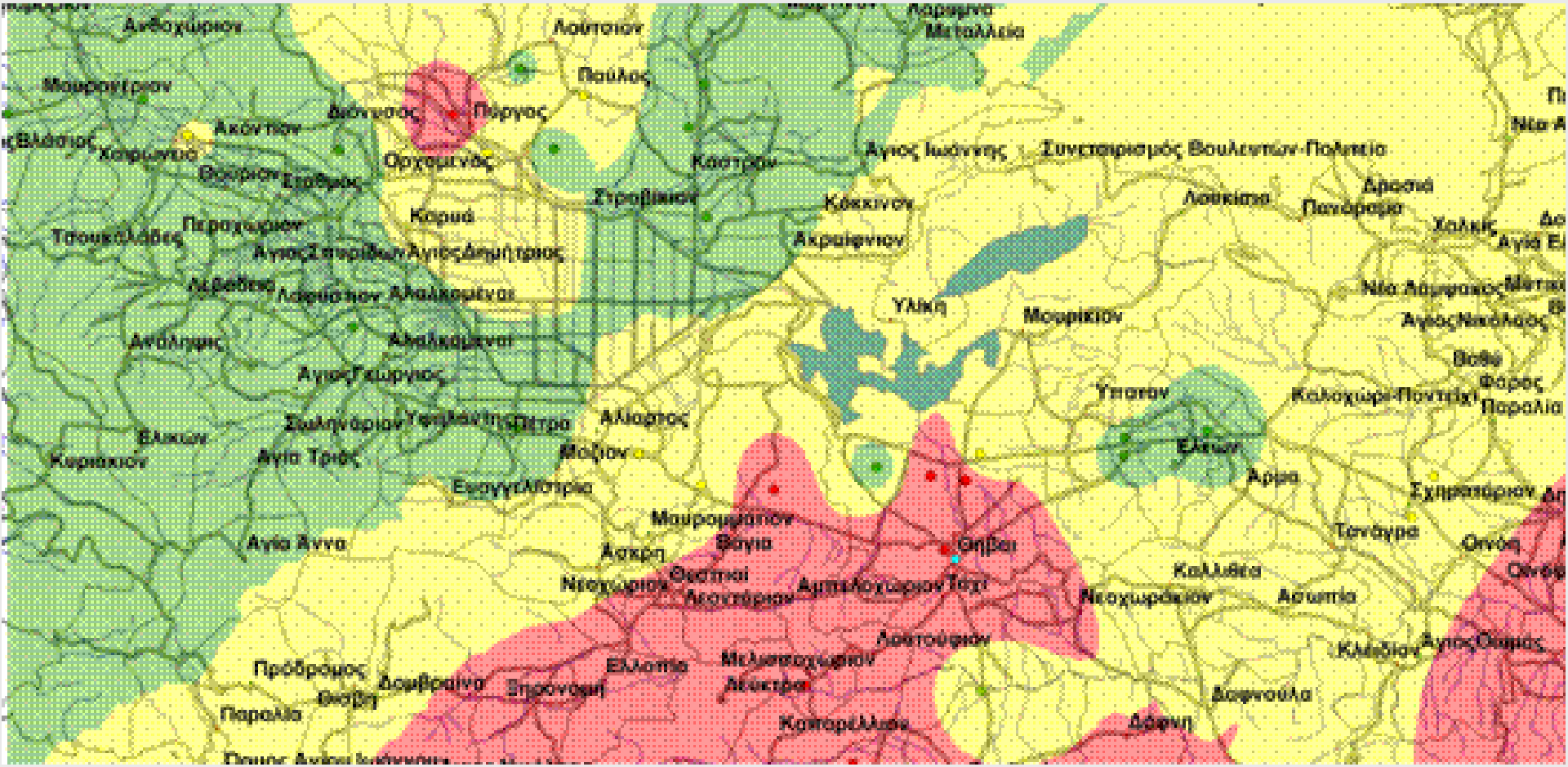


NVZs in Thessaly



Karyotis et al., 2004

Nitrates zones in Voiotikos Kifissos basin



ORIGIN OF NITRATES IN GREECE

Inorganic fertilizers are considered the main sources of water pollution in the intensively cultivated areas in Greece.

Eight Vulnerable Zones to nitrates pollution have been designated.

Regional Action Plans aiming to protect ground and surface water from nitrates pollution have been elaborated.

Codes for Good Agricultural Practices were suggested in the vulnerable areas assisting farmers to improve their management practices

Action Plans and Codes for Good Agricultural Practices must be updated

Rational N fertilization in Voiotia

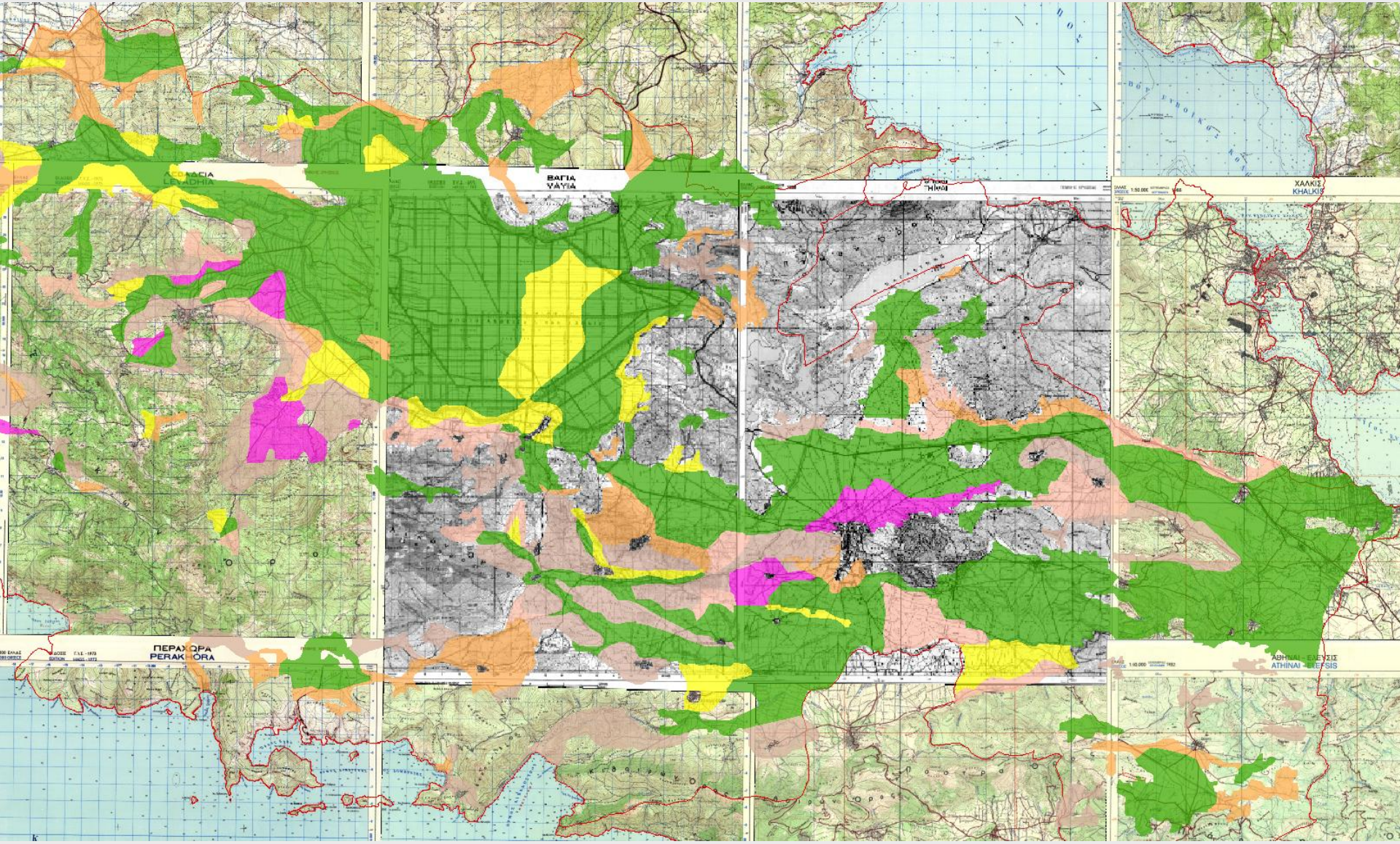
Rational Nitrogen fertilization may be based on:

- Hydrogeological characteristics
- Soil type
- Slope
- Infiltrability
- Irrigation method
- Nitrates content in waters
- Nitrogen requirements in nitrogen
- N Losses (leaching, emissions)
- Climatic conditions

Grouping of soil units

Soil class	slope	texture	hydromorphy
I	plains, <6 %	coarse	moderate-good
II	plains, <6 %	medium	moderate-good
III	plains, <6 %	heavy	moderate-good
IV	plains, <6 %	heavy	insufficient
V	plains, <6 %	coarse- medium	insufficient
VI	hilly, >6 %	coarce	moderate-good
VII	hilly, >6 %	medium	moderate-good
VIII	hilly, >6 %	heavy	moderate-good

Grouped soil units



Compiled by Karyotis and Tsitouras, 2012

Estimation of N inputs and outputs in the soil system

$N_{tot.\,inorg.} = N_s + N_{at} + N_{ir} + N_m + N_f + N_c - N_u - N_v - N_l - N_d$

$N_{tot.\,inorg.}$, total inorganic soil nitrogen (nitrites, nitrates, ammonia e.t.c.)
N_s, residual soil nitrogen
N_{at} from precipitation
N_{ir} from irrigation
N_m by the process of N mineralization
N_f input from fertilizers
N_c upward movement (dry conditions)
N_u taken up by plants
N_v ammonia volatilization
N_l leaching
N_d denitrification

- ***In practice, several parameters may not be accounted for, as their effect on the overall budget is of minor importance.***
- ***Monitoring-measurements may be restricted to nitrogen from N-fertilization, mineralization and plant uptake.***

Nitrogen mineralization dynamics (t=35 °C. t=30 weeks. Q_{10}=1.8)

Profiles	$N_{t35}{}^0t$	$N_{t25}{}^0C$	$N_{t15}{}^0C$	N_0	constant *k*	N_{min} 35	N_{min} 25	N_{min} 15
	mg/kg					kg/ha		
P1	36.25	20.14	11.19	69.39	0.052	153	85	47
P2	39.04	21.67	12.04	80.22	0.058	164	91	51
P3	32.13	17.85	9.92	63.64	0.053	135	75	42
P4	42.77	23.76	13.20	83.91	0.053	180	100	56
P5	38.53	21.40	11.89	73.18	0.050	162	90	50
P6	48.85	27.14	15.08	95.93	0.057	190	106	59
P7	30.72	17.07	9.48	64.77	0.059	129	72	40
P8	58.06	32.26	17.92	115.71	0.054	218	121	67
P9	49.07	27.26	15.14	95.25	0.053	184	102	57
P10	48.17	26.76	14.87	91.02	0.052	188	104	58
P11	55.55	30.86	17.14	107.50	0.054	217	121	67
P12	59.42	33.01	18.34	117.34	0.054	223	124	69
P13	53.49	29.72	16.51	100.88	0.053	209	116	64
P14	57.87	32.15	17.86	104.65	0.049	226	126	70

Nitrogen requirements for targeted yield

Crop	Yield (Kg /ha)	Nitrogen (Kg /ha)
Cotton	4.000	200
Corn	16.000	280
Processing tomatoes	70.000	210

Nutrients inputs in soils from irrigation
Processing tomatoes

	K	Mg	Nitrate nitrogen
	(kg/ha)		
Boreholes	7.6-12.7	53-89	22-36
Surface	2.2-3.6	53-88	6.1-10
Wells	7.1-12	129-215	34-57

Soil classes	
I	Coarse texture, slope 0-6%, good hydromorphy
II	Medium texture, slope 0-6%, intermediate hydromorphy
III	Fine texture, slope 0-6%, intermediate to insufficient hydromorphy

Crop	Soil class	Irrigation system	Fertilization units/ha		
			N	P	K
Cotton	I	sprinkler	150	80	70/3 years
		drip	120	80	70/3 y
	II	sprinkler	140	80	70/3 y
		drip	120	80	70/3 y
	III	sprinkler	140	80	70/3 y
		drip	110	80	70/3 y
Corn	I	sprinkler	150	75	75/3 y
		drip	160	75	75/3 y
	II	sprinkler	180	75	75/3 y
		drip	160	75	75/3 y
	III	sprinkler	200	75	75/3 y
		drip	120	75	75/3 y
Processing tomatoes	I	drip	110	70	210/3 y
	II	drip	90	70	210/3 y
	III	drip	80	70	210/3 y

Conclusions

1. **Soil survey demonstrated a significant variation in a number of soil properties such as texture, nutients content, drainage etc.**

2. **Most soils contain calcium carbonate, the content of organic matter is low, while the level of total nitrogen is at normal level**

3. **Exchangeable potassium is low in most soils and enhancement of potassium fertilization is required. With regards to magnesium no problems were recorded**

4. **Available phosphorus varied significantly among soils due to different quantities of fertilizers applied by producers and the crop history**

5. **Iron, copper, manganese and boron were at normal levels, while zinc in a number of samples was at deficiency level**

6. **The content of nutrients, especially in surface horizons was significantly influenced by topography, drainage, surface runoff and cultivation practices**

7. The Advisory fertilization should be based on the use of soil analysis and leaf or plant tissue analysis

8. Rational nitrogen fertilization practice was suggested for the main crops. It is based on crop requirements for a targeted yield, nitrates in irrigation water and N mineralization

9. The use of nitrogenous fertilizers revealed that no increased content were recorded in the parcels of farmers evolved in the project for the implementation of Nitrates Directive

10. Farmers not included to the aforementioned project apply an empirical fertilization method and they use higher quantities of N fertilizers

11. The recommended fertilization in the framework of EcoPest can decrease the inputs about 24.78% in comparison to the empirically applied fertilizers

12. With the proposed fertilization treatment a significant reduction of nitrogen fertilization can be achieved, while the application of fertilizers in more doses can increase the nitrogen use efficiency.

13. Even greater reduction of N fertilization is possible with the application of fertigation

14. Reduction of nitrates can be implemended through a set of measures including: better effectiveness of N use, extension of drip irrigation, cultivation of suitable crop varieties

15. Usage of improved techniques e.g. drip irrigation, fertigation, application of linear fertilization, etc.


THANK YOU VERY MUCH