Defence of forest ecosystems against fires

a case of study of environmental planning & management

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Mytilene - May 2003

Facts

- Forest fire defence planning is a multi-faceted task
  - Causes of fire: human caused, natural
  - Non modifiable factors: weather, wind, topography
  - Modifiable factors: forest fuels, causes of fires
  - Infrastructures: roads, lookouts, water points
  - Fighting resources: aerial forces, ground forces

Facts

- The different components are not independent
  - Causes of fire ⇔ Forest fuel ⇔ Weather
  - Forest fuel ⇔ Topography ⇔ Weather and wind
  - Initial fire ⇔ Infrastructures ⇔ Fighting resources
- They are linked in space and time
  - Position in the landscape
  - Moment of appearance / action

Objective: to know when and were factors match in space and time and change dynamically in their evolution

Proposal

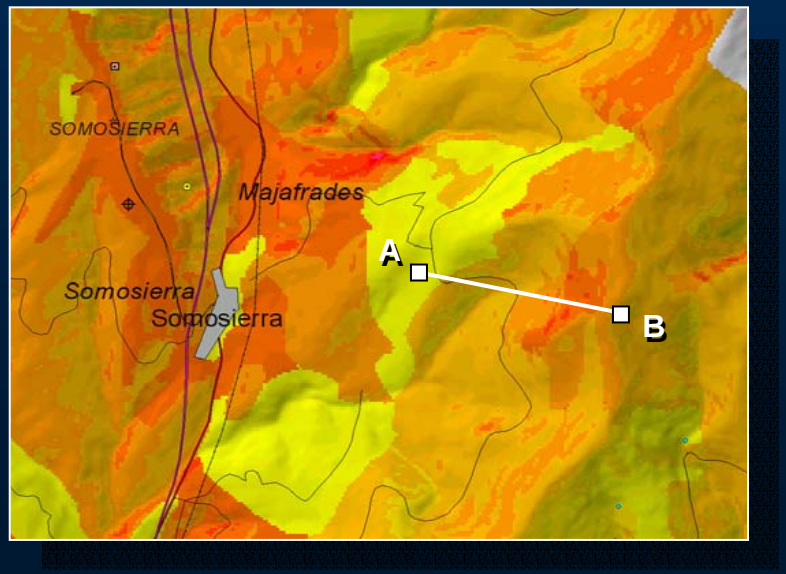
Madrid Regional Government (Spain) asked us for a comprehensive planning procedure, we proposed:

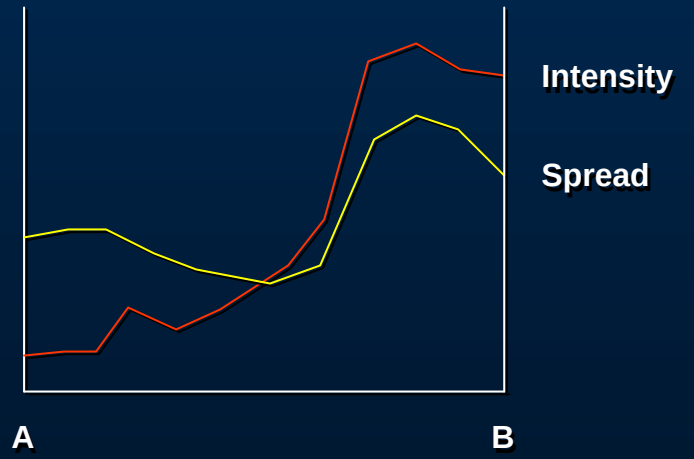
- To co-ordinate the application of criteria, and
- to make combined analysis of factors

Information Systems and models helped to make such multi-faceted, time and spatial-dependant analysis

New methods
Analysis of cross-sections

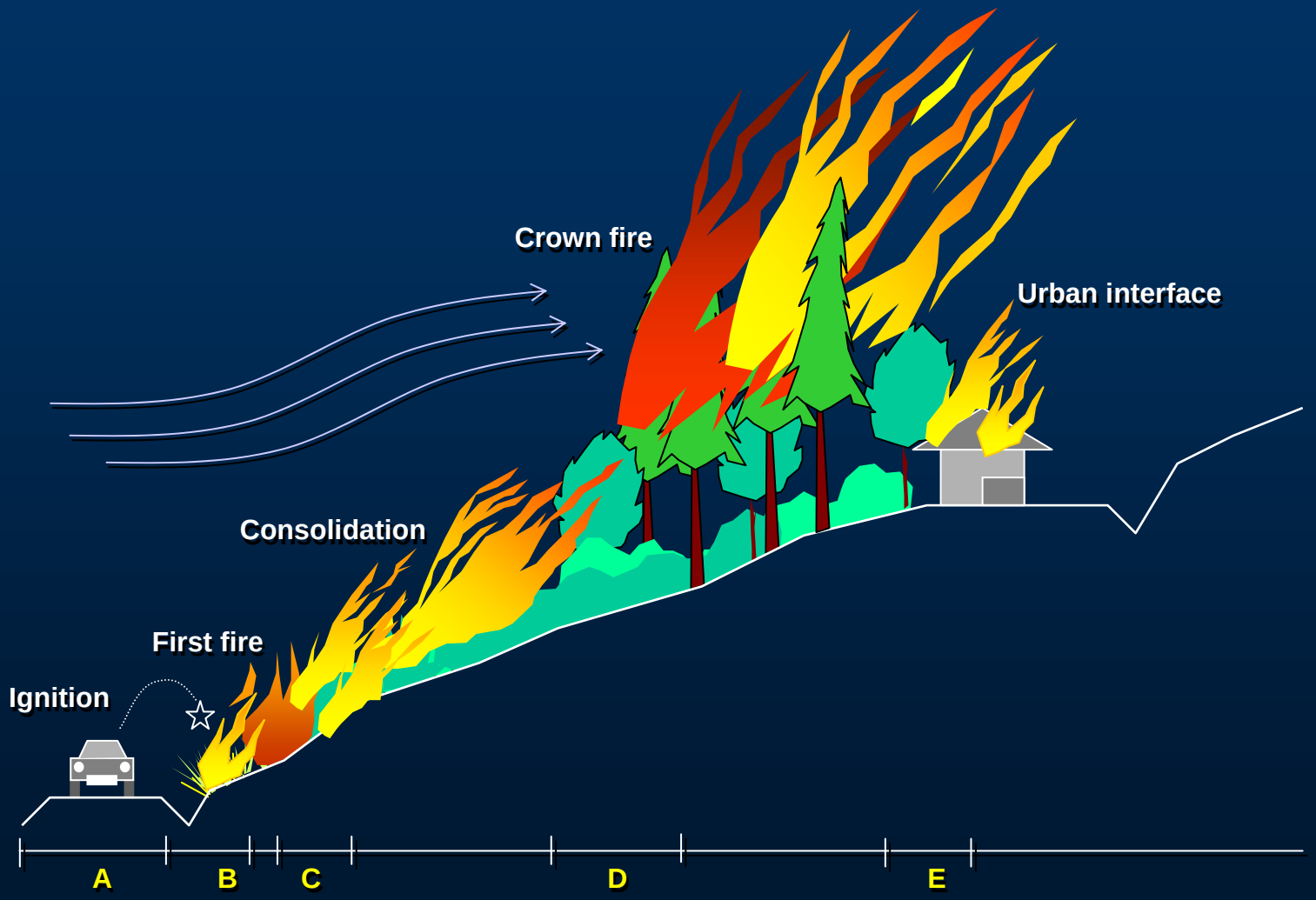
- Instead of just analysing point properties, it is proposed to study cross-sections of terrain
  - Ignition potential
  - Evolution of fire spread rate
  - Evolution of fire line intensity





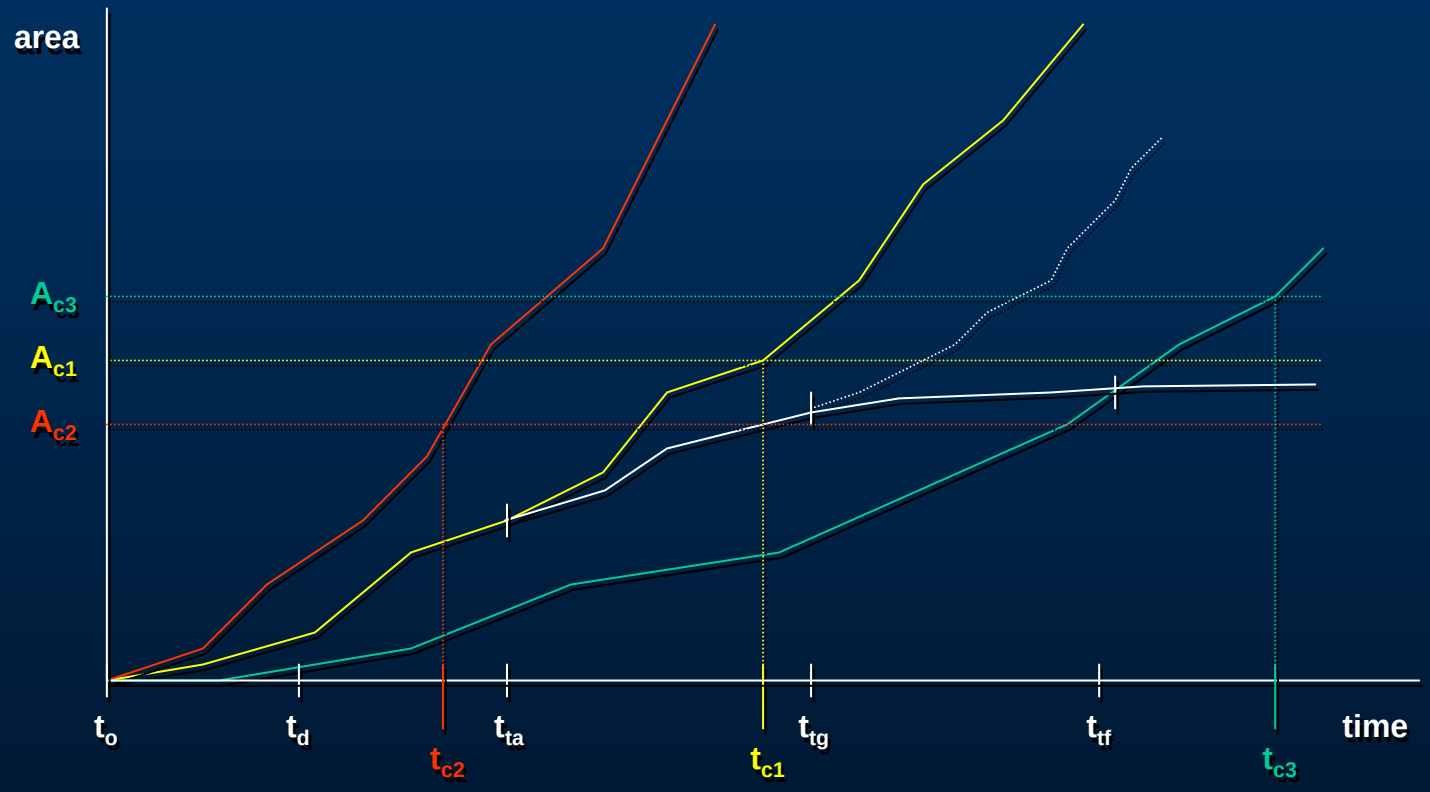
New methods

Transition Areas



New methods

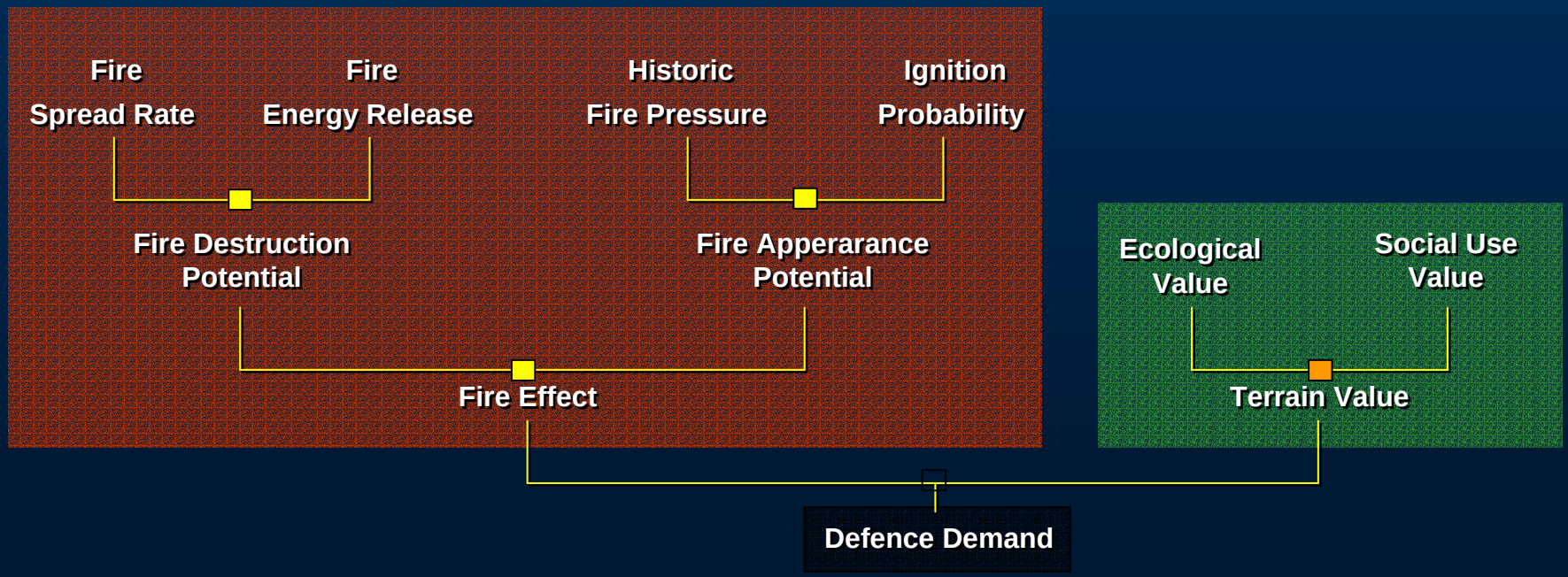
Analysis of time



Forest Fire Defence Demand

Defence Demand
Scheme of calculation

According to responsibles of FF defence, a minimum but meaningful set of components should be integrated in a single concept:



Defence Demand
Inventory of fire landscape

Prior to the calculation of Defence Demand components, a detailed inventory of forest fire landscape elements had to be completed:

- Topography
- Forest fuels
- Weather and wind patterns
- Historical records of fires

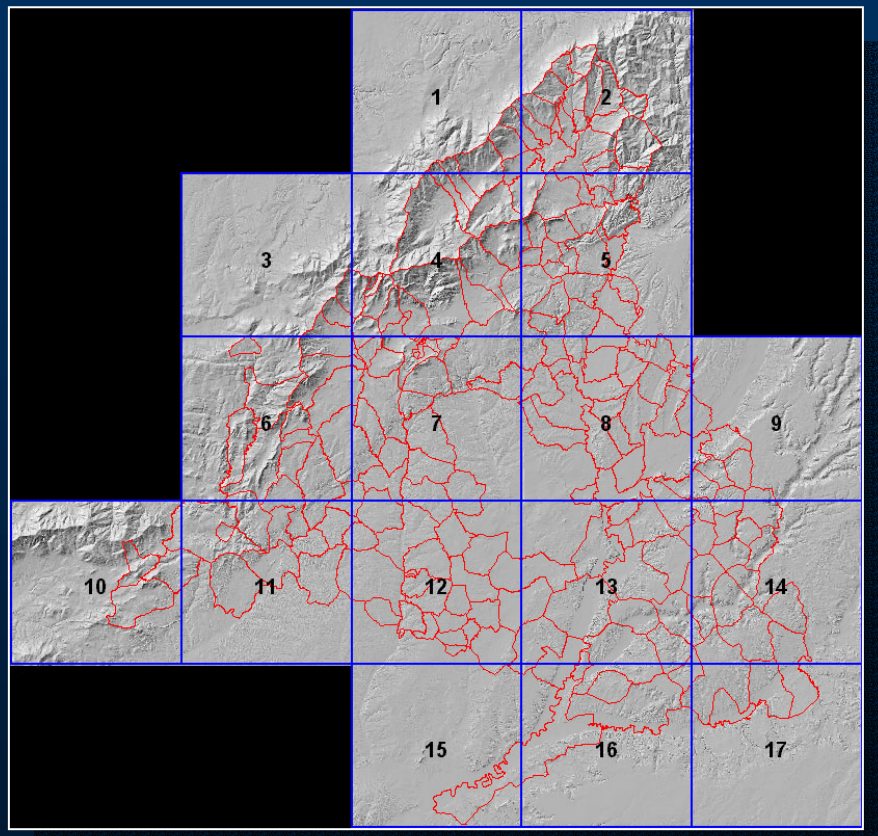

MAR CANTÁBRICO
FRANCIA
OCÉANO ATLÁNTICO
PORTUGAL
MAR MEDITERRÁNEO
AA
ACO
CAR
BRIF
ACT
HK

Overview
The scenario

Madrid province is located in the geographical centre of Spain and its surface spans over 780.000 ha

A mountainous range running NE to SW dominates the landscape

Territory is divided into 138 municipalities



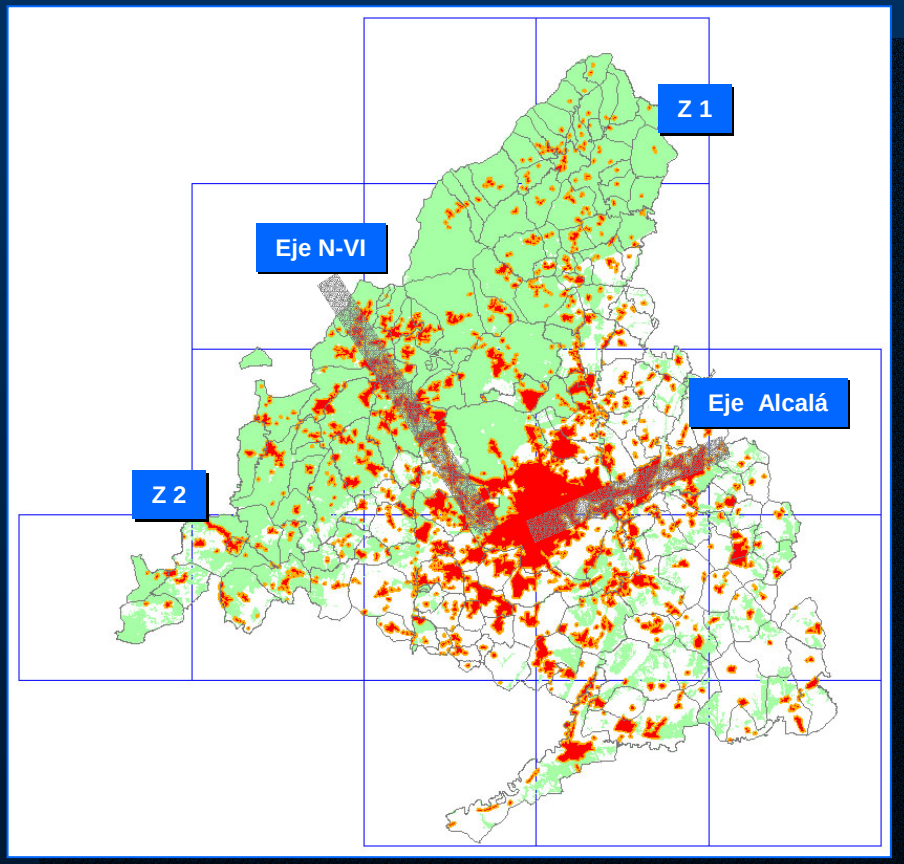
Overview
The scenario

Madrid metropolitan area of around 4 million people is in the centre of the province

Forested areas are located mainly in the north and are visited by 1 million each weekend

Wildland-Urban Interface is patent along main highways

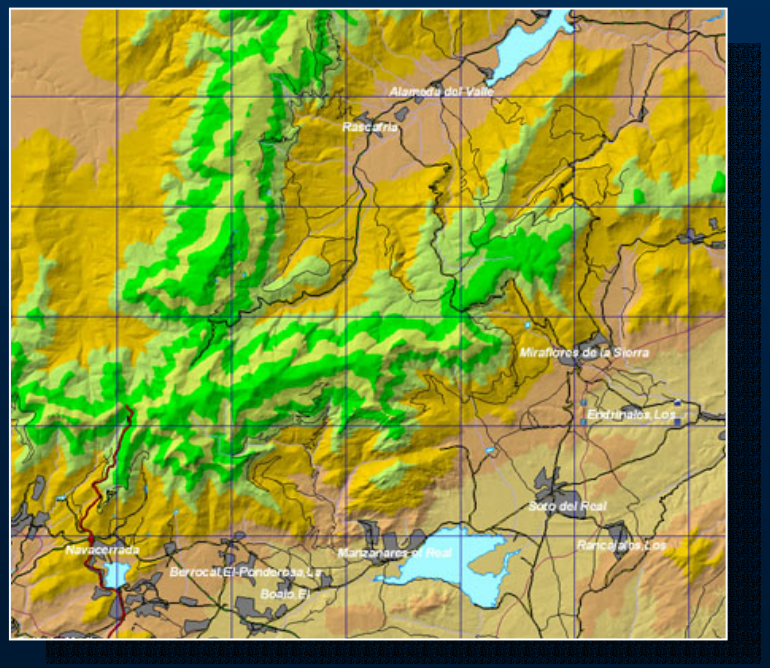
Territorial development grows continuously



Defence Demand
Inventory of fire landscape

- A number of basic maps were elaborated and stored under the same geographical information platform

  - Digital Terrain Model
  - Slope & aspect
  - Vegetation coverage
  - Rivers, reservoirs
  - Administrative boundaries



Defence Demand
Inventory of fire landscape

Forest fuels were sampled, focusing especially in the determination of active fuel load

250 sampling plots of 10x10 meters were used

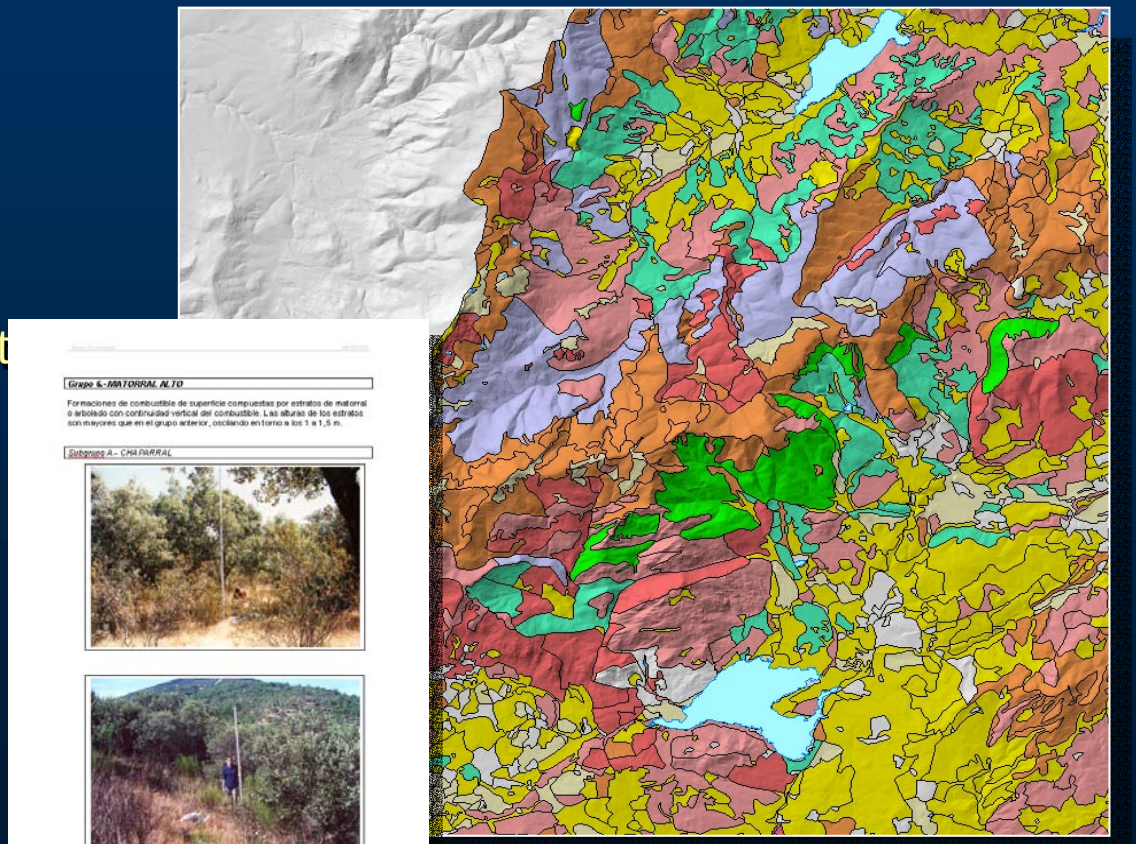
A complete catalog of fuel complexes was done

A total of 40 different variants were grouped into 11 main classes

Defence Demand
Inventory of fire landscape

The resulting fuel characterisation was extended to the rest of vegetation plots, obtaining a surface forest fuel map

A visual key was edited containing key identification cues



Grupo 6.-MATORRAL ALTO

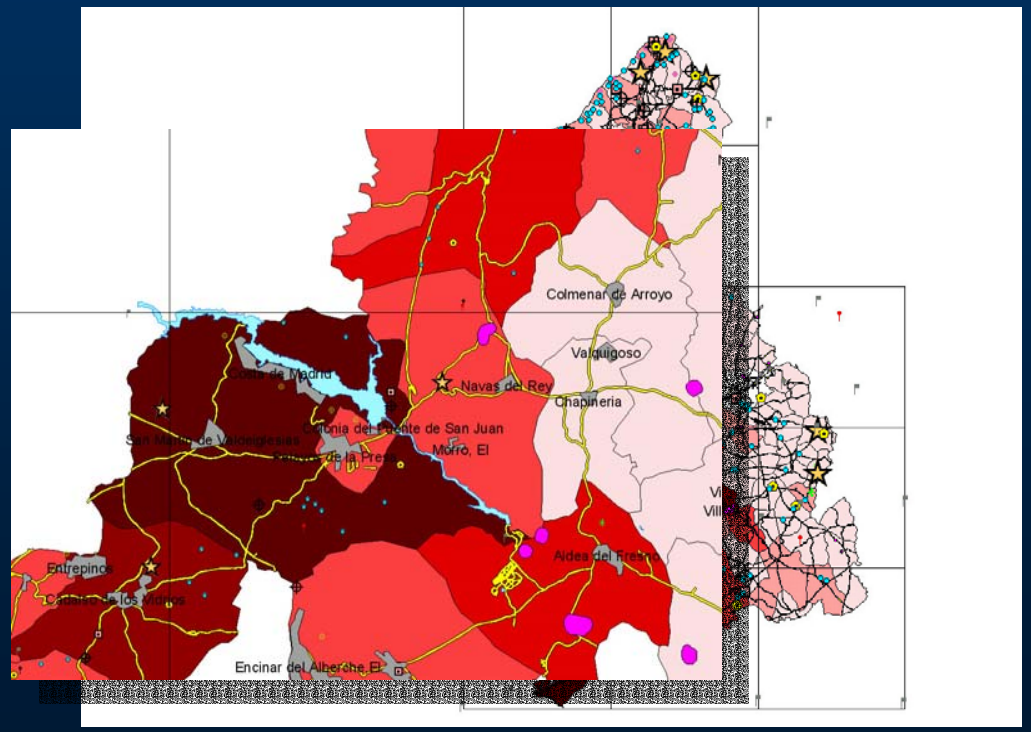
Formaciones de combustible de superficie compuestas por estratos de matorral o arbolado con continuidad vertical del combustible. Las alturas de los estratos son mayores que en el grupo anterior, oscilando en torno a los 1 a 1,5 m.

Subgrupo A - CHAPARRAL

Defence Demand
Inventory of fire landscape

Historical Fire Pressure was obtained from National ESTADIS database for the past 10 years

Number and causes of fires were charactrerised by municipality

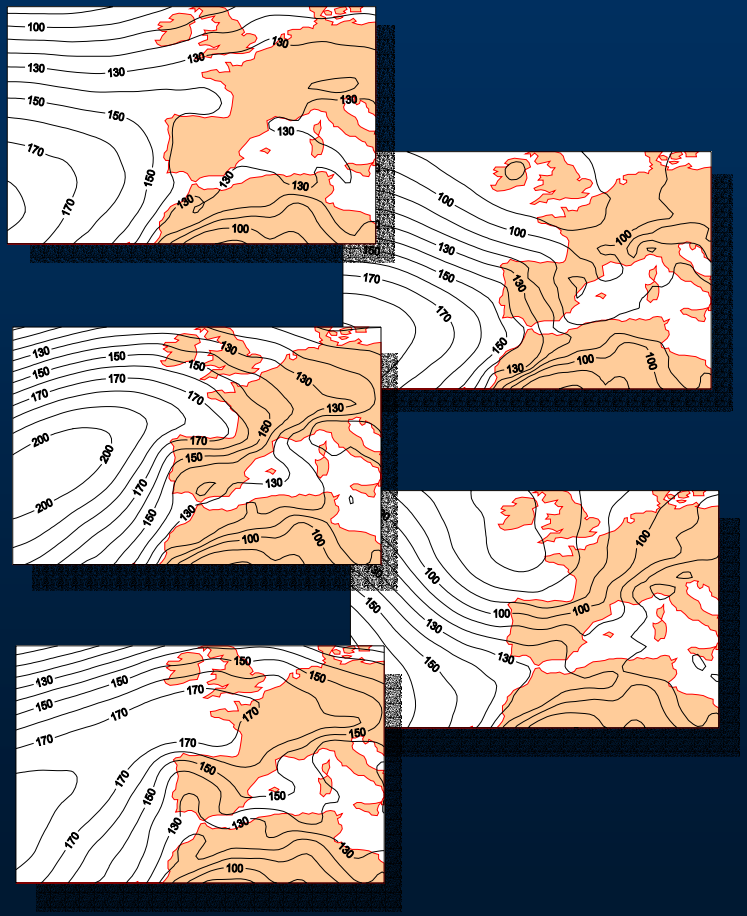


Defence Demand
Inventory of fire landscape

A meteorological & wind patterns study was done using historical observations

A set of 5 Average Adverse Conditions were identified as typical in Madrid

These patterns should be used in the calculations

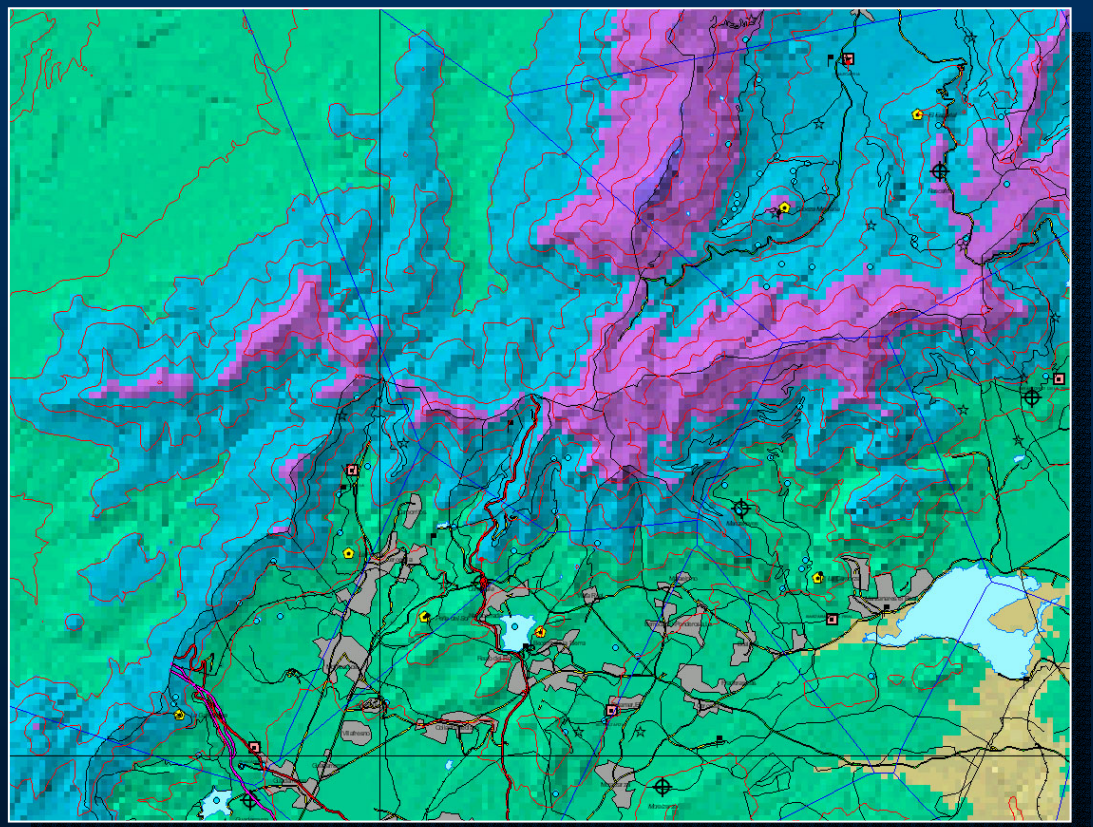


Defence Demand
Calculation of components

Probability of ignition is estimated from air temperature and relative humidity (DGCONA)

Correction due to topography, insolation and cloud coverage

Fine fuel moisture content is a key factor in its estimation

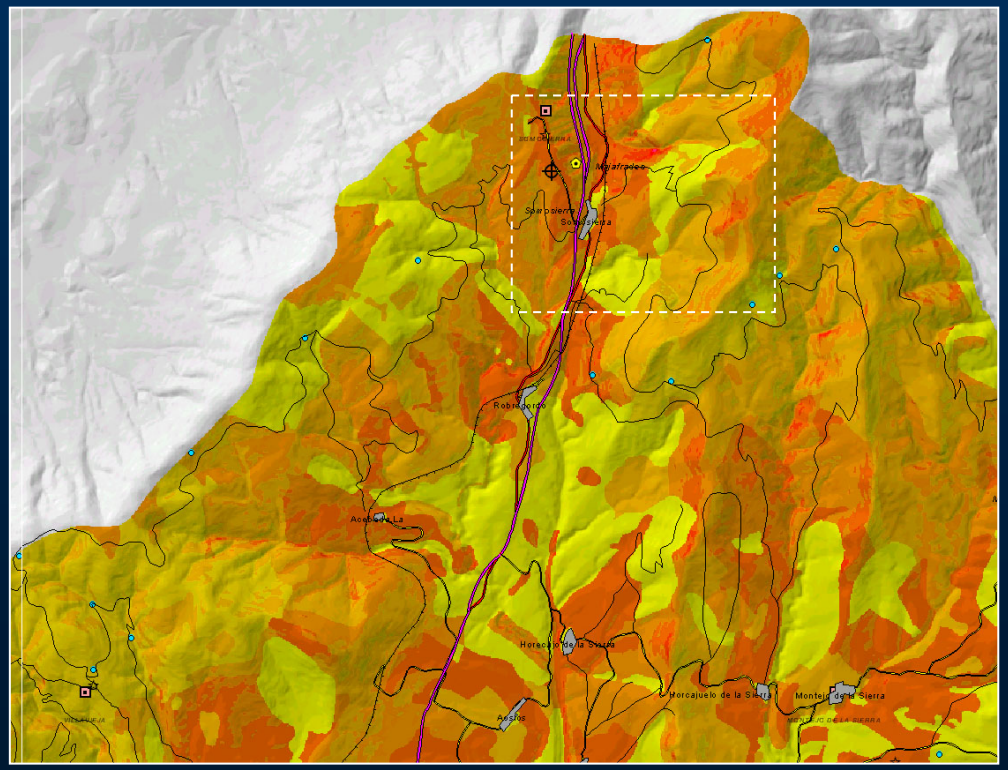


Defence Demand
Calculation of components

Potential Fire Spread Rate was calculated using Rothermel equations

Potential Fire Intensity was calculated using Byram equation

Both values were classified into four ranges: Low, Average, High and Very High



Defence Demand
Integration of components

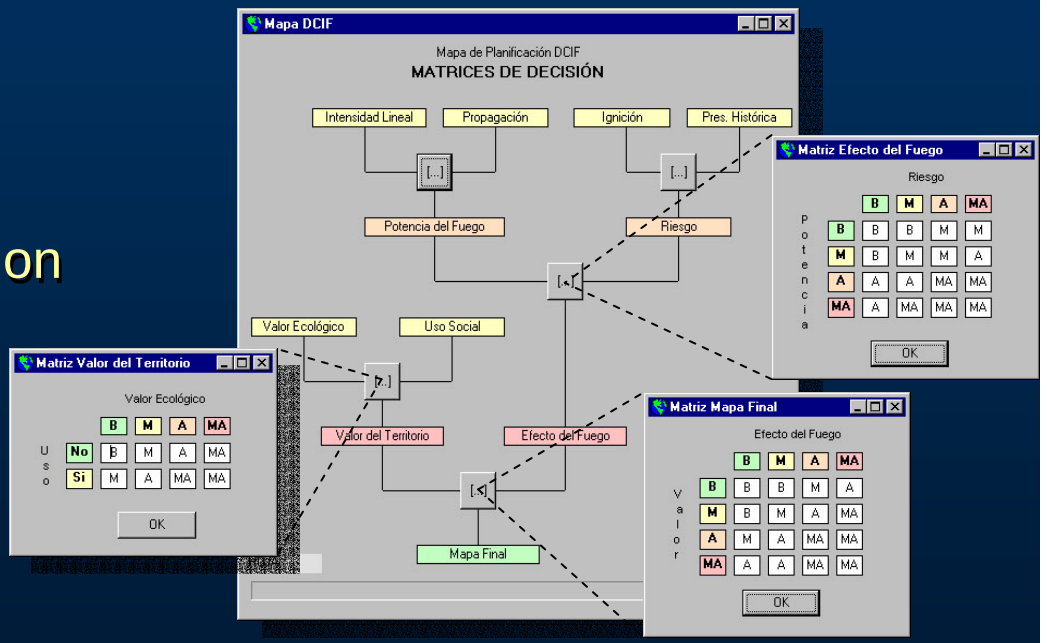
- Components are integrated using classification matrixes
- Obtained by scoring all possible combinations
- Involving an panel of experts and managers on a set of subjects to do the ranking:
  - Forest fires
  - Civil protection
  - Environment
  - Natural resources,
  - Territorial development, etc.

	L	A	H	VH
L	L	L	A	A
A	L	A	A	H
H	M	H	H	VH
VH	H	H	VH	VH

L= Low A = Average H = High VH = Very High

Defence Demand
Integration of components

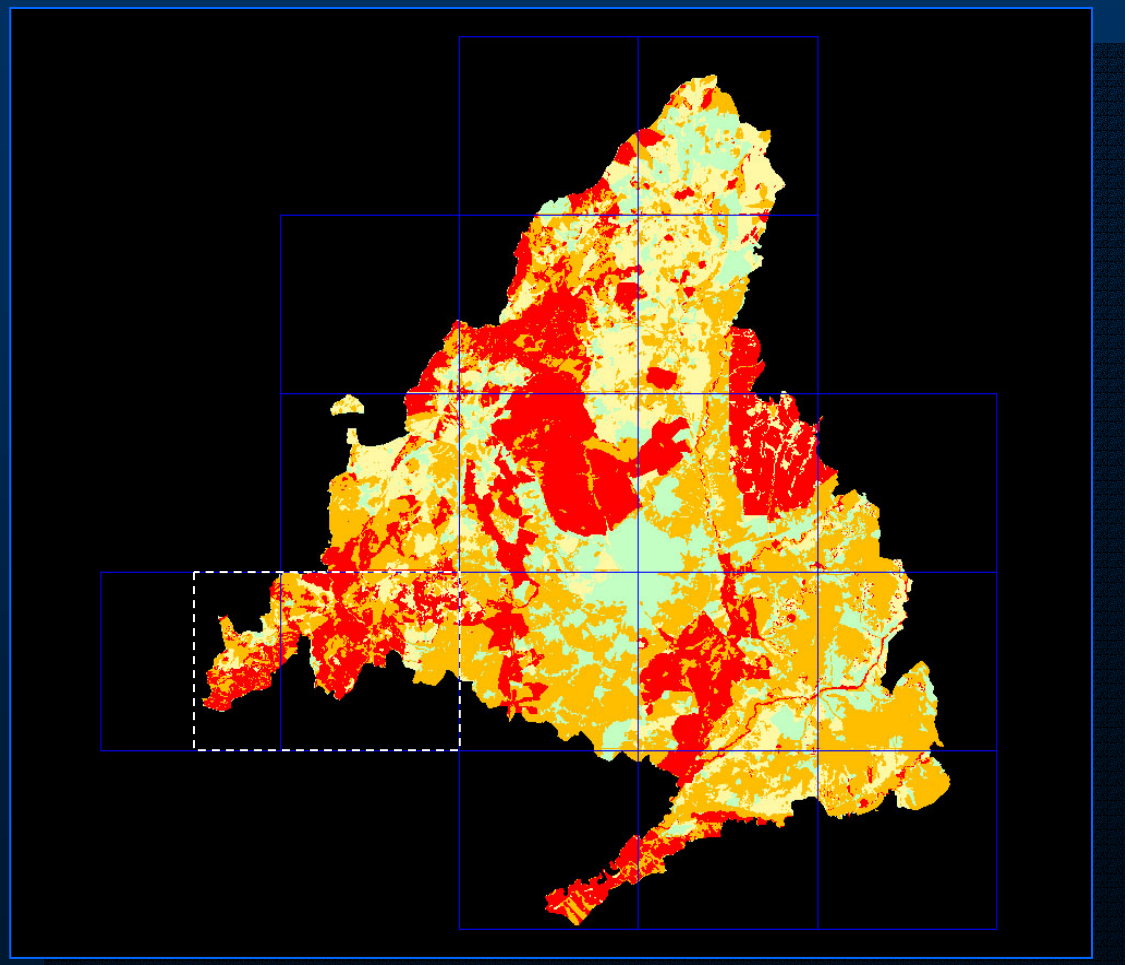
- Components classification using matrixes can be automated (MATRICES program)
- Certain conditions can be tested on the fly
- Values in the matrixes can be changed



Defence Demand
Final map calculation

Final map is shown in four colours:

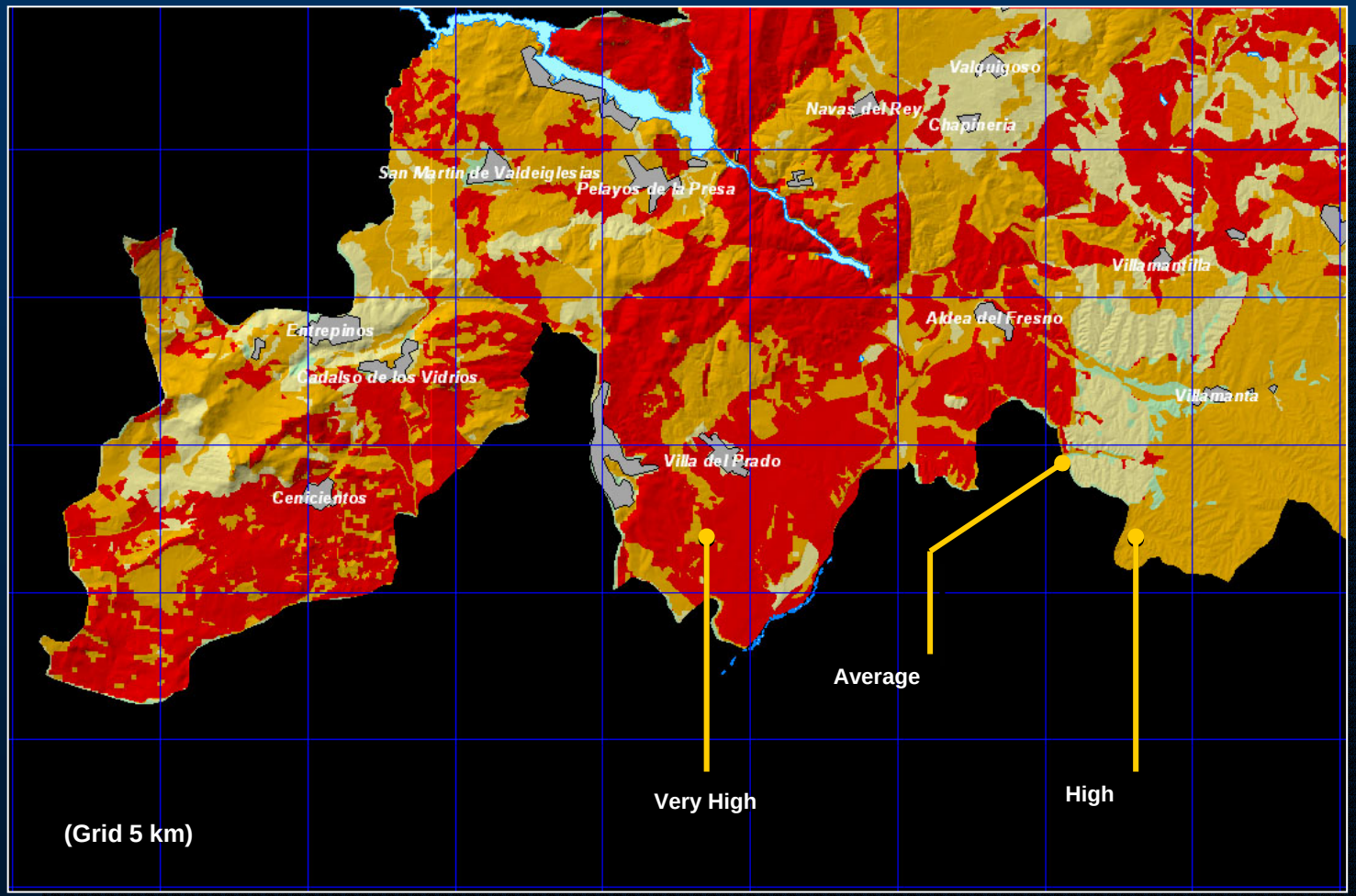
Low
Average
High
Very High



It has shown to be

- **Understandable**
- **Comparable**
- **Meaningful**

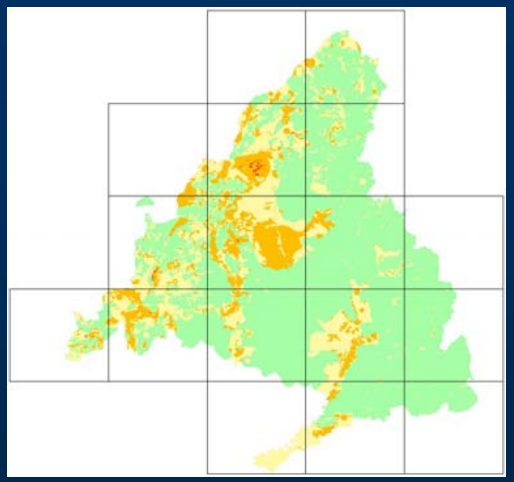
Defence Demand
Final map calculation

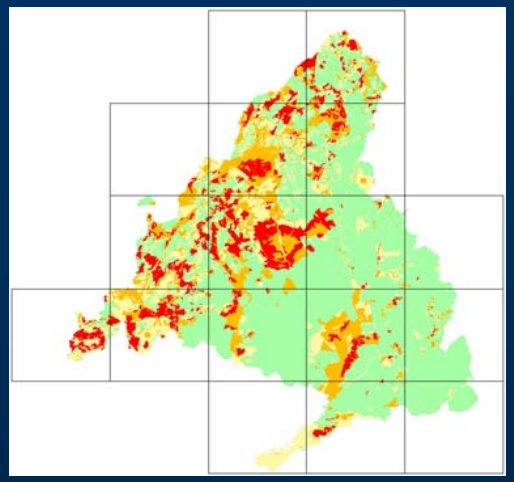


Defence Demand

Some real examples (year 2000)

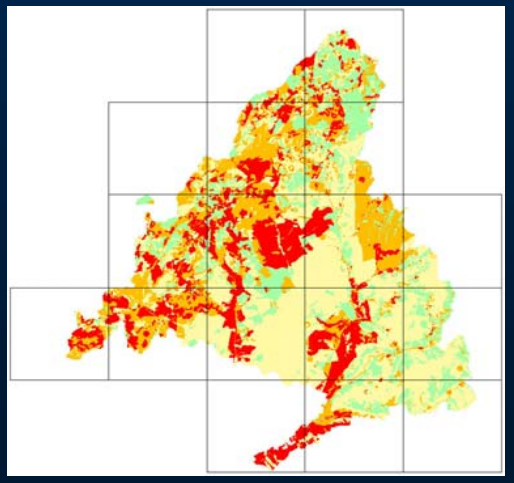
Situation 1
No wind
Low Tº
High HR

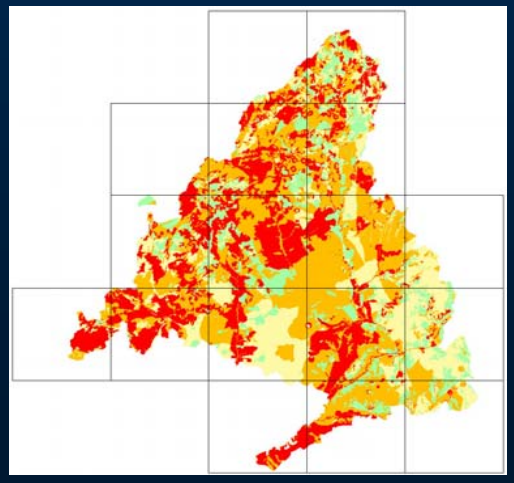




Situation 2
Low wind
Medium Tº
Medium HR

Situation 3
Medium wind
High Tº
Low HR



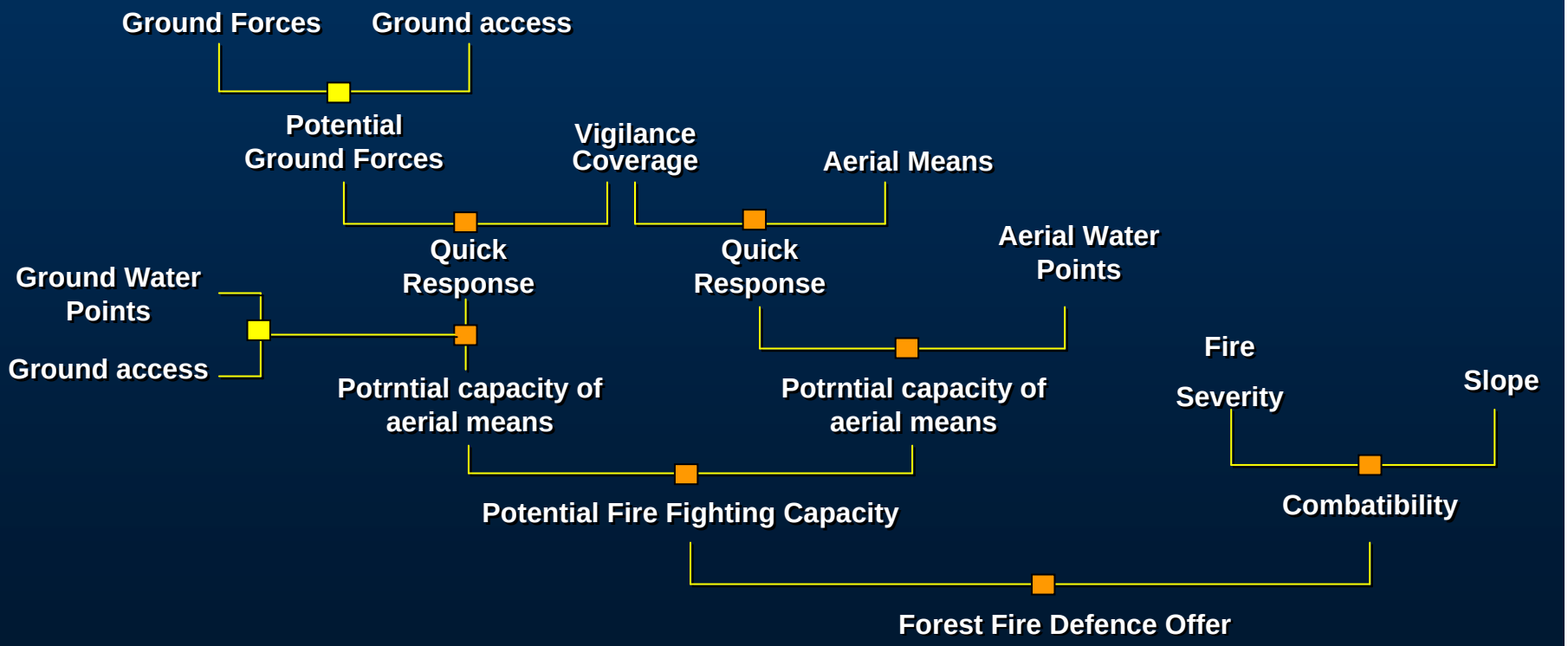


Situation 4
Strong wind
High Tº
Very low HR

Forest Fire Defence Offer

Defence Offer
Scheme of calculation

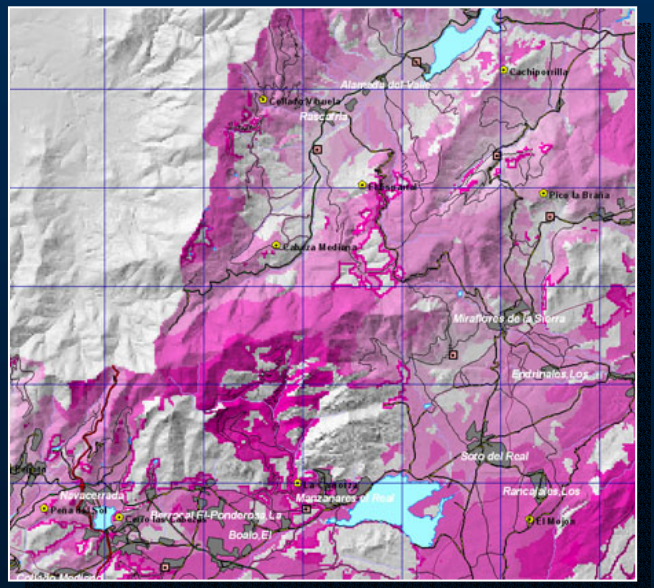
A number of components are similarly integrated into a single concept:



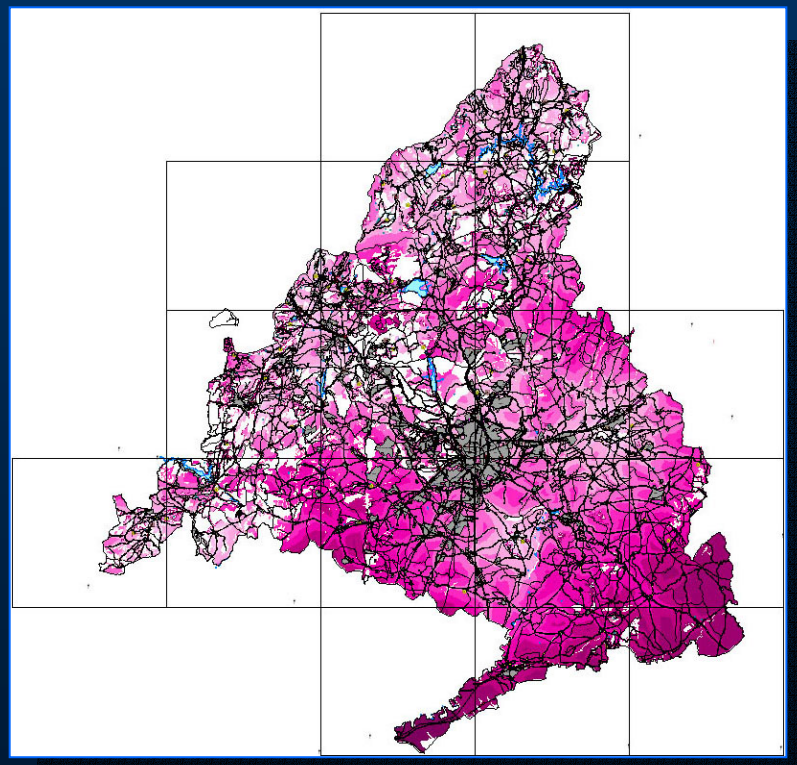
Defence Offer
Inventory of resources

Prior to any calculation a detailed inventory of resources and infrastructures must be done:

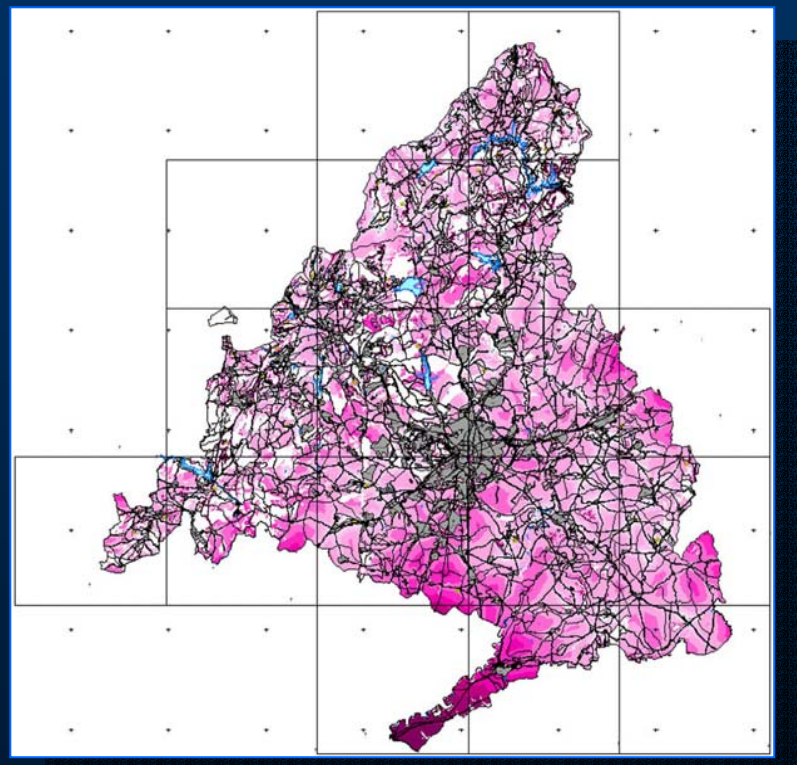
- Road network
- Fire fighters bases
- Heliports and airports
- Vigilance lookouts
- Water points
- Communication antennas
- Meteorological stations, etc.



Defence Offer
Ground forces accessibility



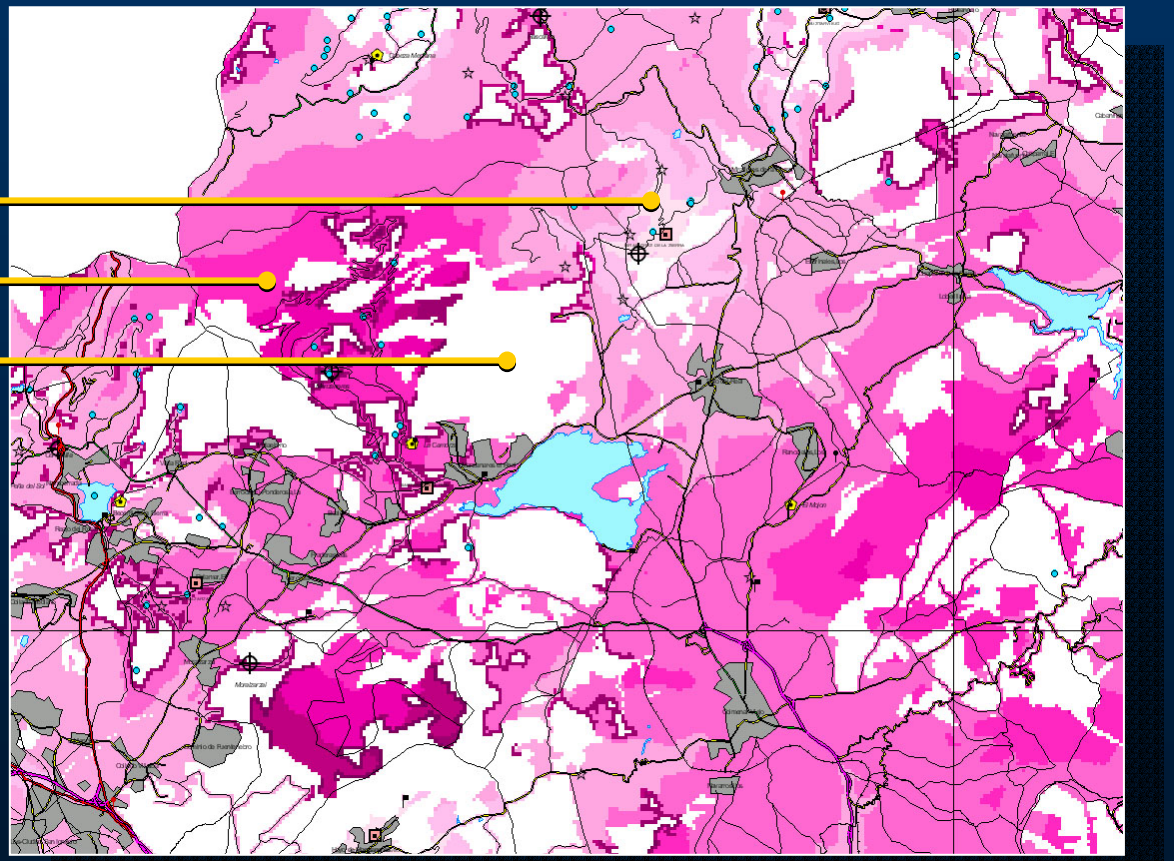
Ground access time to **BASES**



Ground access time to **WATER POINTS**

Defence Offer
Ground forces accessibility

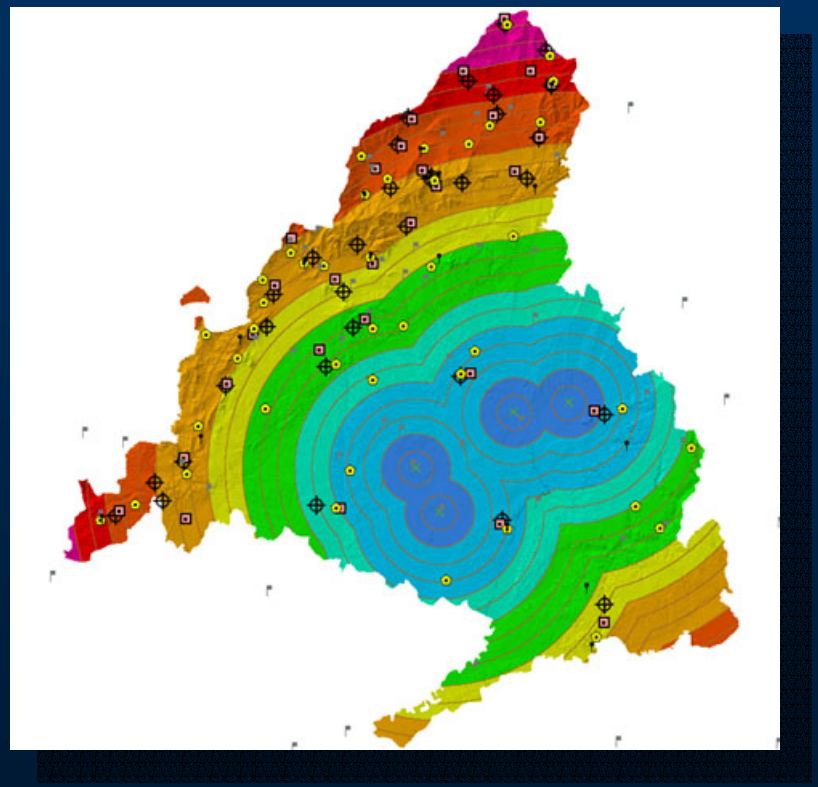
Expressed in minutes spent to reach a point



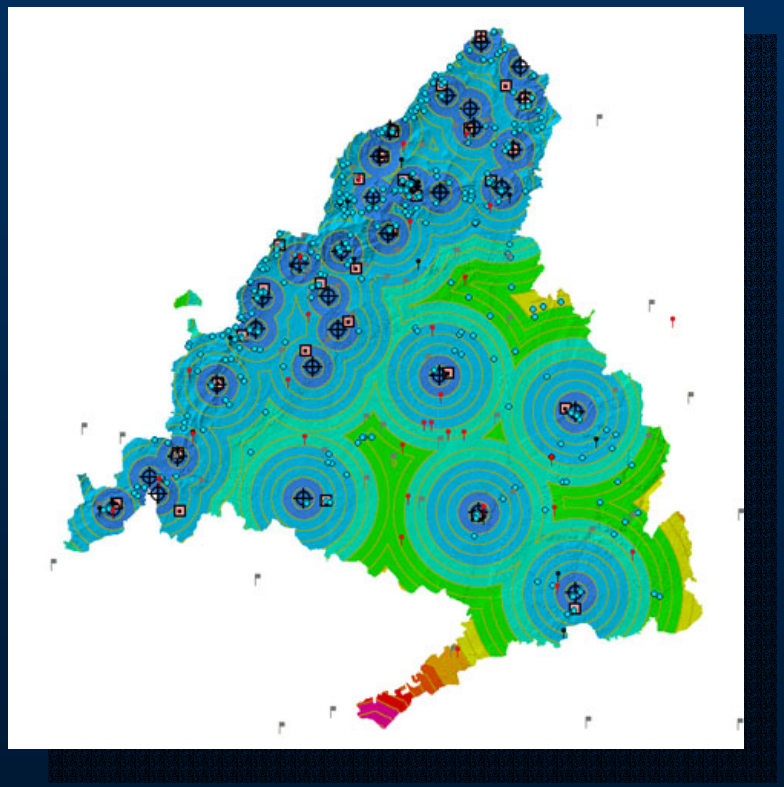
Accounting:

- **Road network**
- **Slope**
- **Rock presence**
- **Vegetation coverage**

Defence Offer
Aerial accessibility



Aerial access time from **AIRPORTS**



Aerial access time from **WATER POINTS**

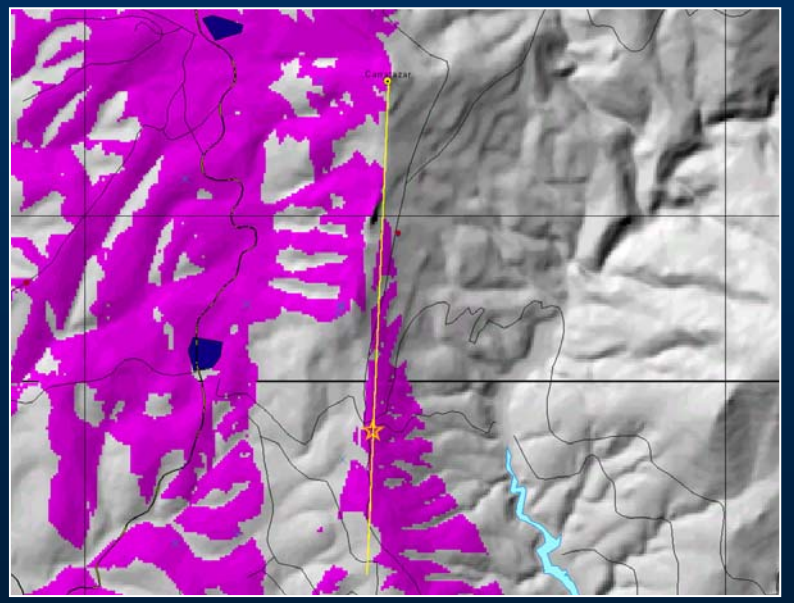
Defence Offer
Lookouts viewshed

Fixed vigilance coverage is estimated by viewsheds

Viewshed is corrected and validated by panoramics

Panoramics are used also in fire detection as “visual cues”

Viewshed



Panoramic

Final Analysis: Demand vs. Offer

Defence Demand vs Offer
Analysis of results

Offer and Demand are compared and combinations are scored by experts & managers according to consequences of the observed differences:

Values
L Low
A Average
H High
VH Very High

		OFFER			
		L	A	H	VH
DEMAND	L	0	+1	+1	+3
	A	-1	0	+1	+2
	H	-2	-1	0	+1
	VH	-3	-2	-1	0

Hence, every point in the territory has a value from -3 to +3

Defence Demand vs Offer

Zoning for planning

Such values define a zoning which can be used for planning:

Zone 0: Equilibrium

Zone 1: Defective offer

Zone 2: Excessive offer

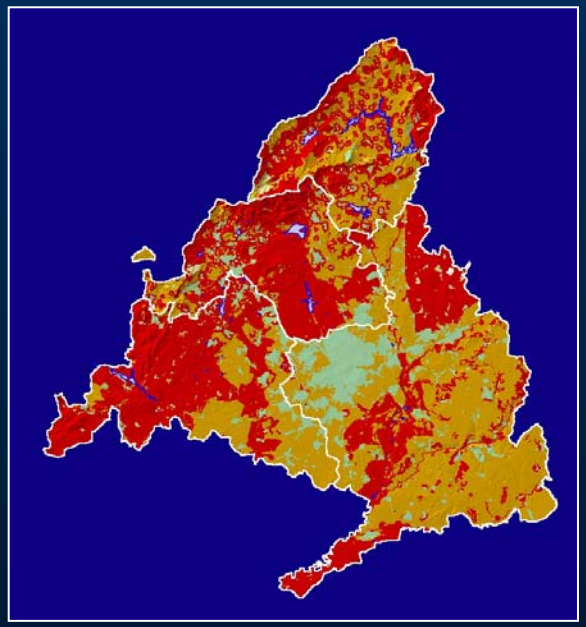
Zone 3: Minor impact

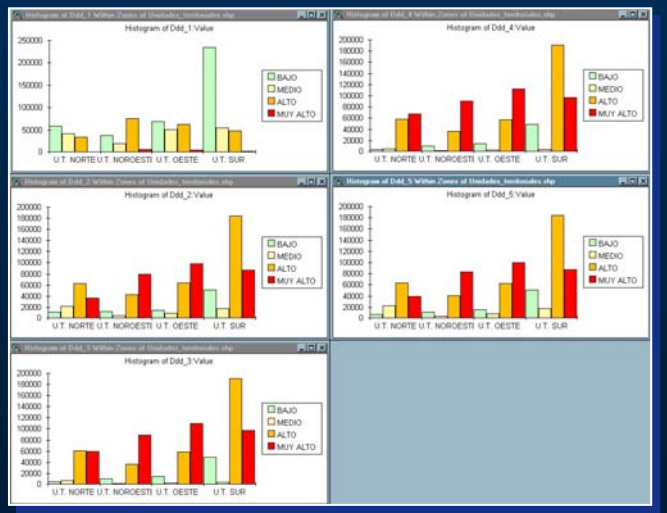
1	-3	VH	L	ZONE 1
2	-2	VH	M	
3	-2	H	L	
4	-1	VH	A	
5	+3	L	VH	ZONE 2
6	+2	M	VH	
7	+1	H	VH	
8	+1	M	H	
9	-1	H	M	ZONE 3
10	-1	M	L	
11	+1	L	H	
12	+1	L	M	

Defence Demand vs Offer
Zoning for planning

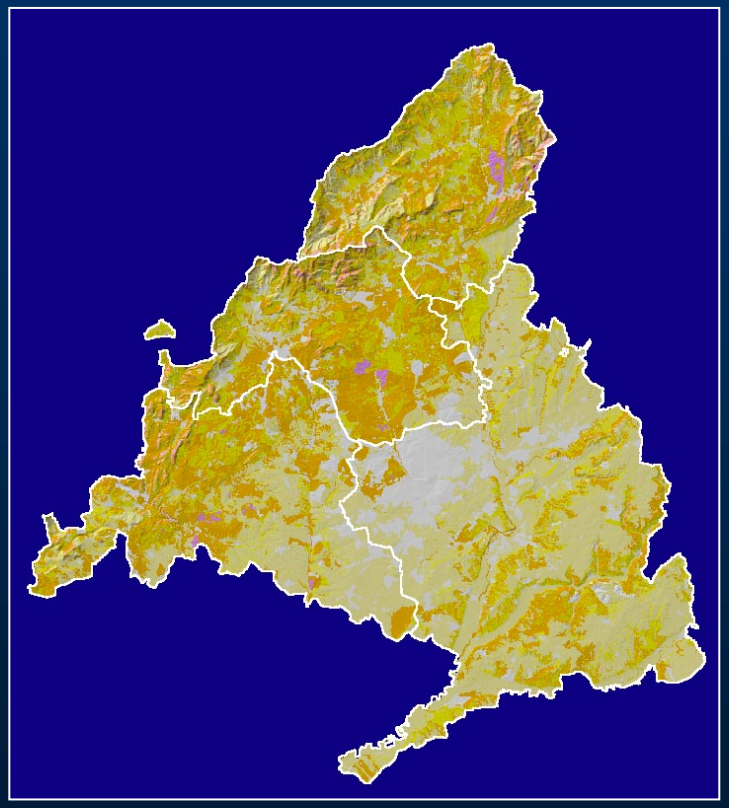
- ZONE 0. Very low priority. Well covered area.
- ZONE 1. Defective offer. Actions: Reduction of fuel load or change fuel type. Improve road network. Improve number and position of ground and helicopter bases. High priority
- ZONE 2. Excessive offer. Actions: Move resources to Zone 1 where it is possible. Change budget and reallocate it. Average Priority
- ZONE 3. Less impact. Act in the sense as shown in ZONE1 and ZONE 2. Low priority

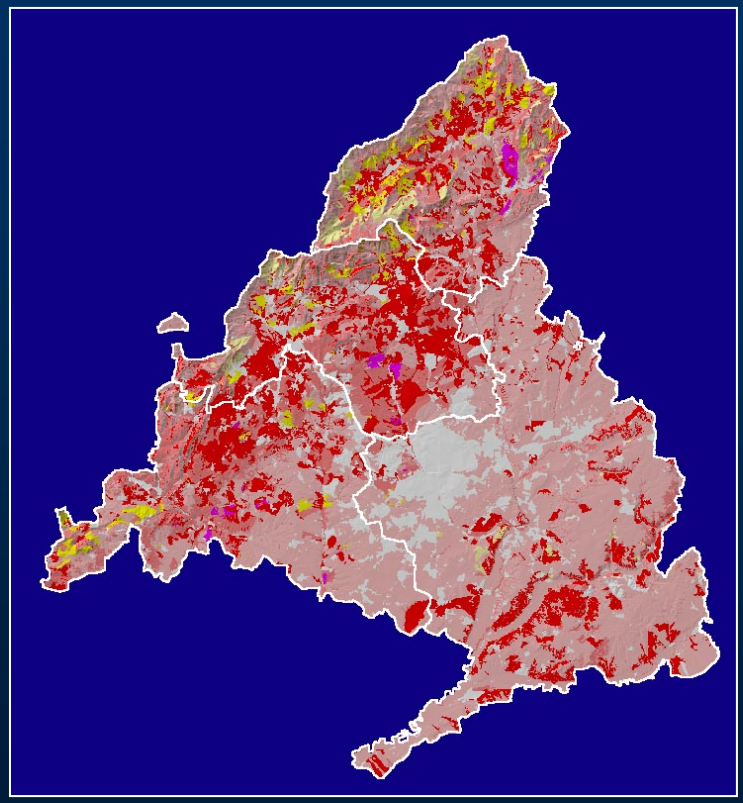
Zoning & prioritisation





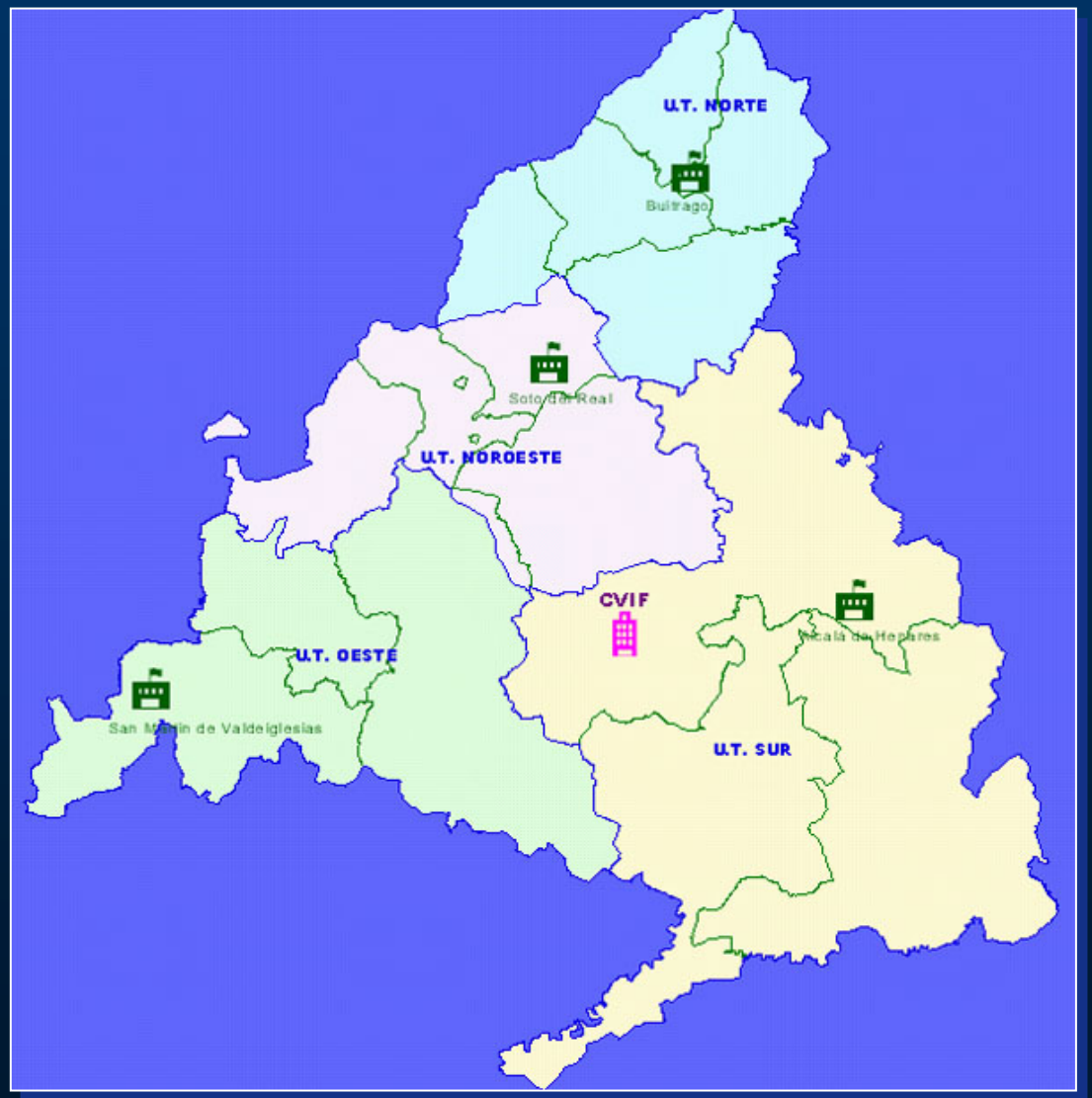
Zoning & prioritisation



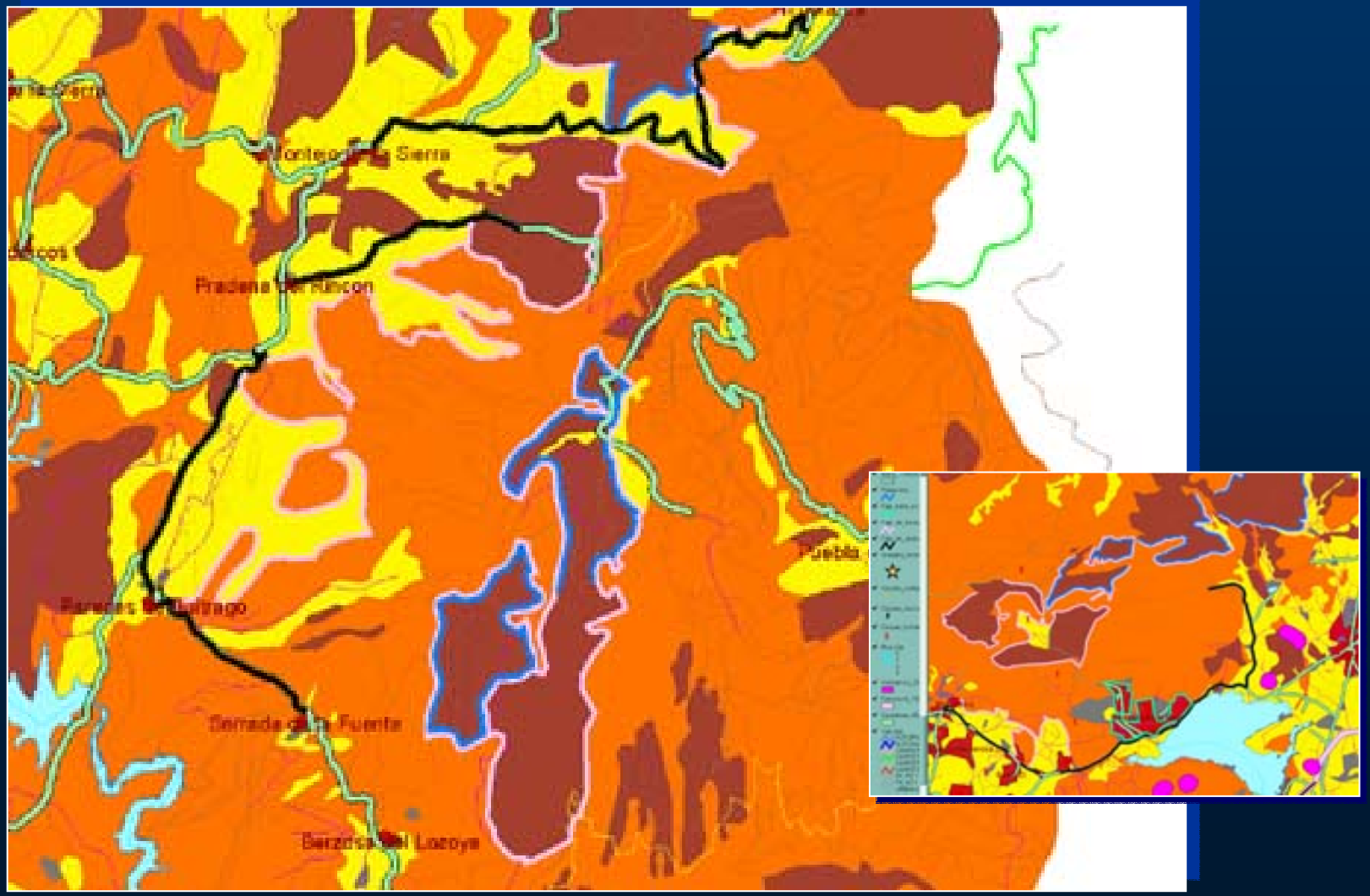


Fire effect calculated based on fire intensity and rate of spread

Organisational structure

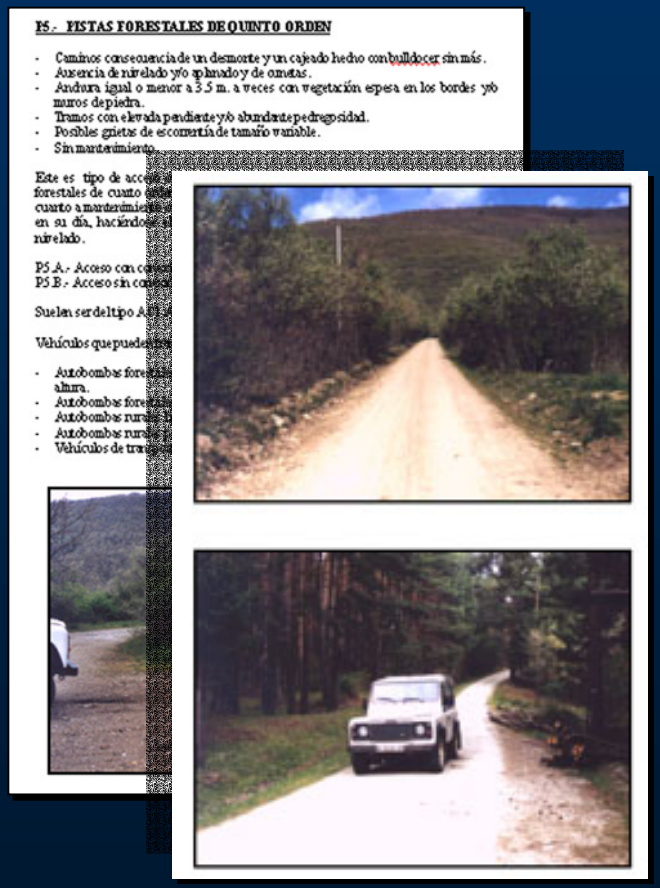


Forest Fuel Treatments



Infrastructure planning

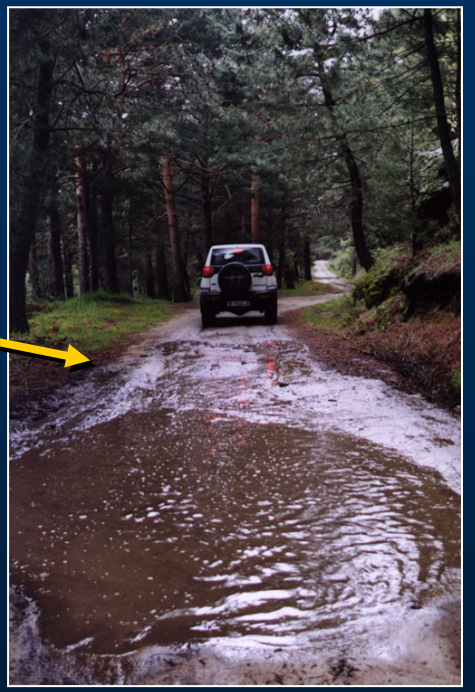
- **Roads and forest roads CATALOGUE**
- **Measurement of driving time**
- **Digitisation and NETWORK analysis**



Infrastructure planning

Works

- **Needs identification**
- **General improvements proposal**
- **Particular improvements**



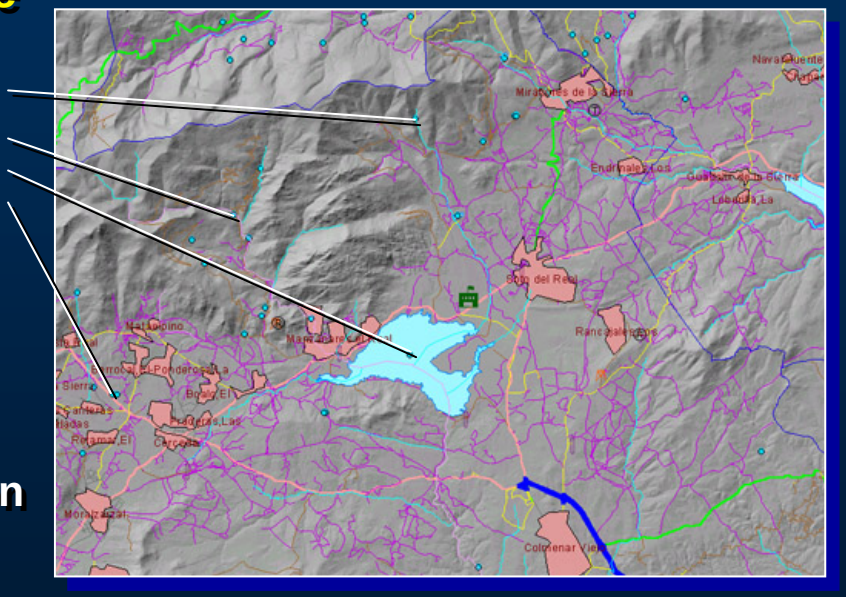
Infrastructure planning

Water points network modifies fire defence OFFER

- Ground resources
- Aerial means

Works planned at local level

- Adequate water point network
- Adequate number and type of suppression means



Vigilance & detection

U.T. NORTE

12 Lookout po

U.T. NOROESTE

13 PUESTOS FIJOS

U.T. OESTE

9 PUESTOS FIJOS

U.T. SUR

12 PUESTOS FIJOS

Information & assessment system

Territorial Centres:

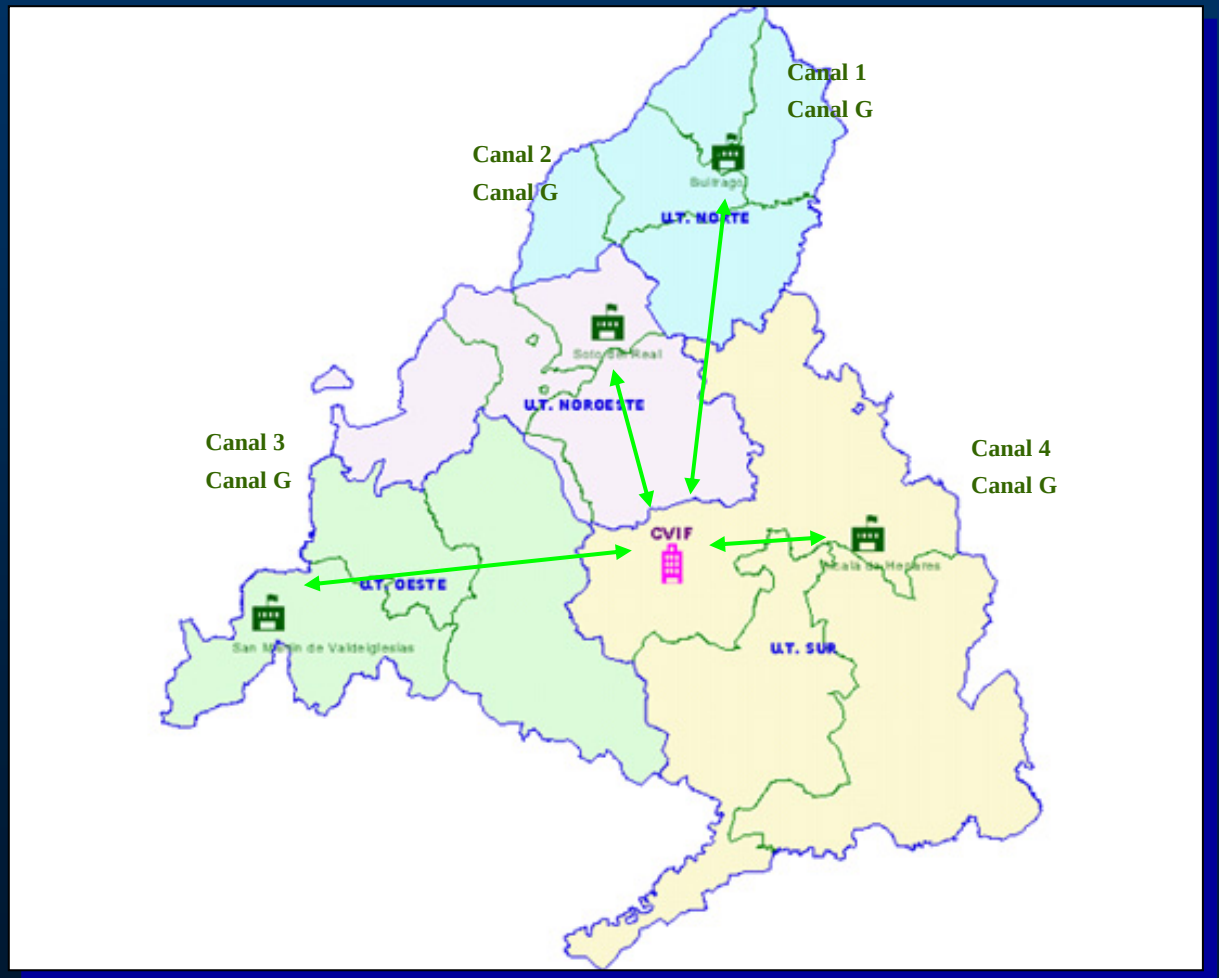
CODIF

Information & Assessment System

PROTOCOLS

Forest Fire Assessment Central

CVIF



Fire suppression

Regional resources

1 Co-ordination helicopter

2 Fighting helicopter

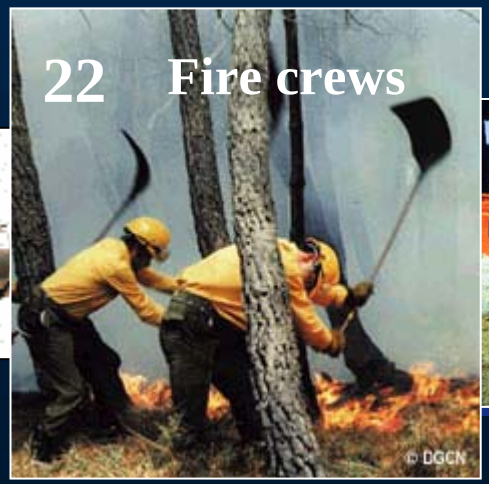
2 Vehículo nodriza

1 Movil unit

3 Bulldozer

Fire suppression

Local resources



Fire suppression

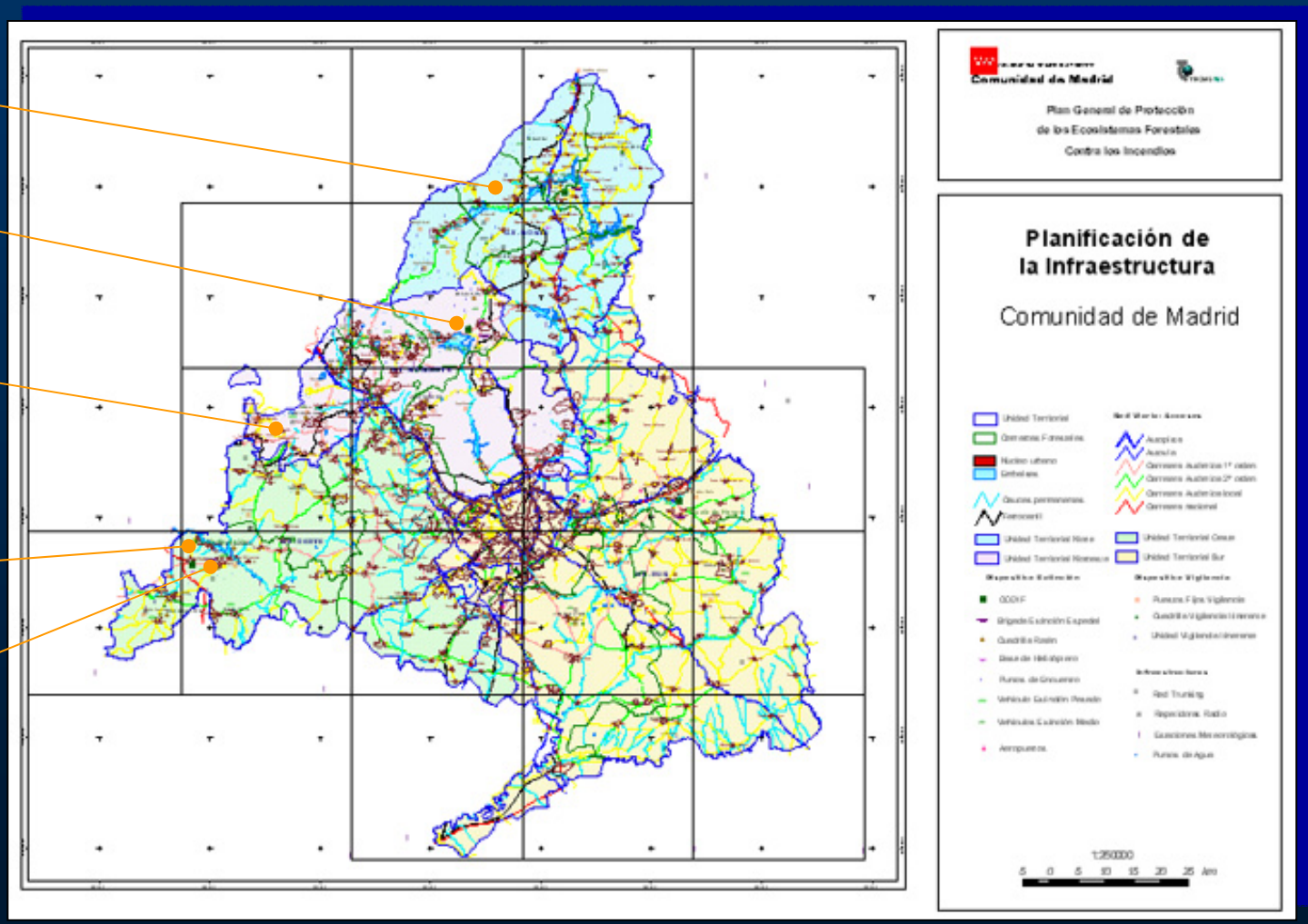
Territorial Unit

Operational Center

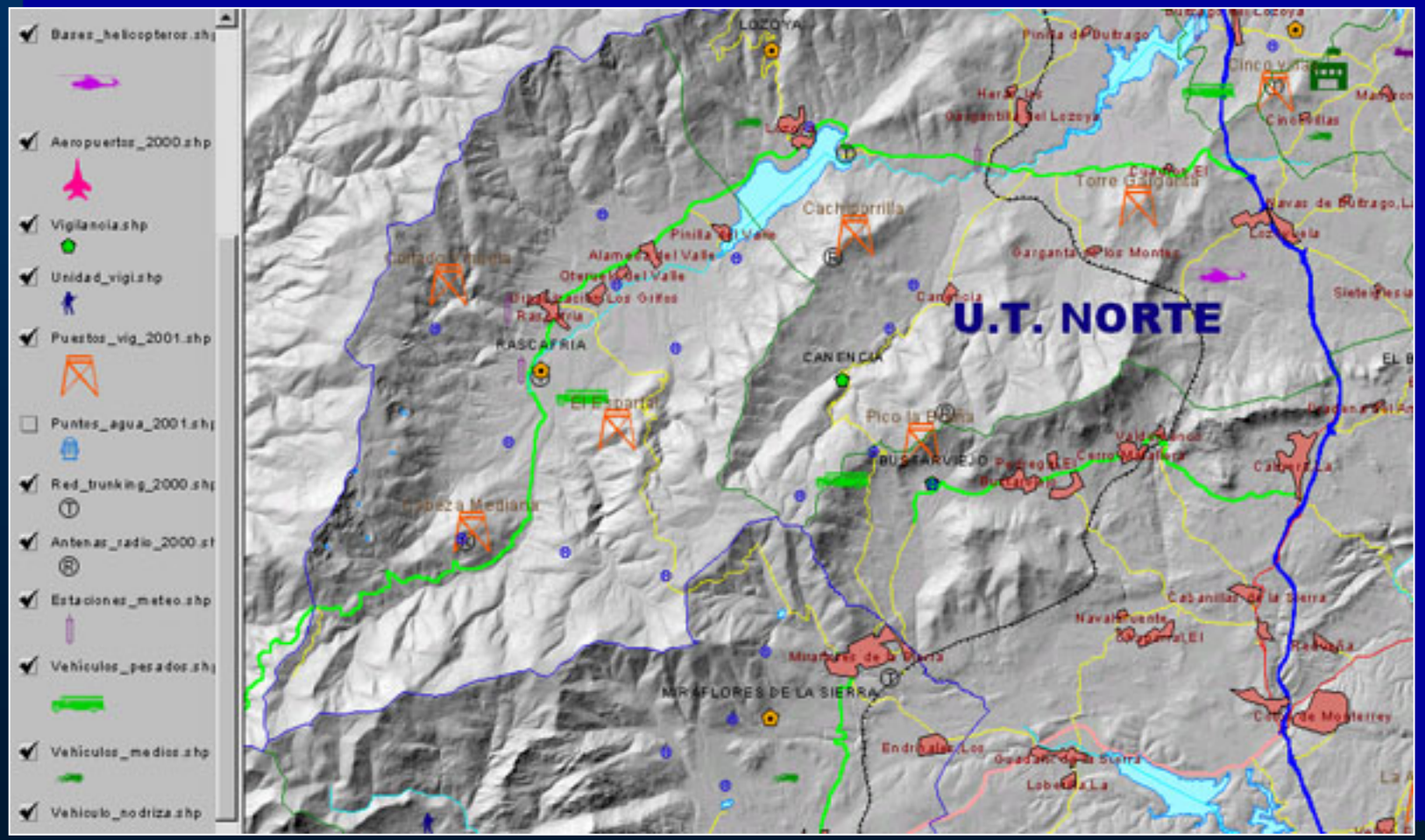
Suppression Units

Fire trucks

Aerial means



Fire suppression



Conclusions

- It is necessary to integrate components in FF defence planning under the same time - space co-ordinates
- Actions on modifiable factors have several effects, all must be considered and their inter-relations
- It is proposed to prepare, or at least to know, the fire scenario in advance by preventive planning
- Territory zoning according to the comparison of demand & offer helps to optimise and adequate planning tasks and prioritise activities
- Information systems help a lot in the application of these methods


Heyxaristó !