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Fire modeling data preparation for test area of Zlatograd municipality, Bulgaria

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ՀՌՆԱՊ ARNAP DRR NATIONAL PLATFORM
AMERICAN UNIVERSITY OF ARMENIA Center for Responsible Mining
Funded by European Union Civil Protection

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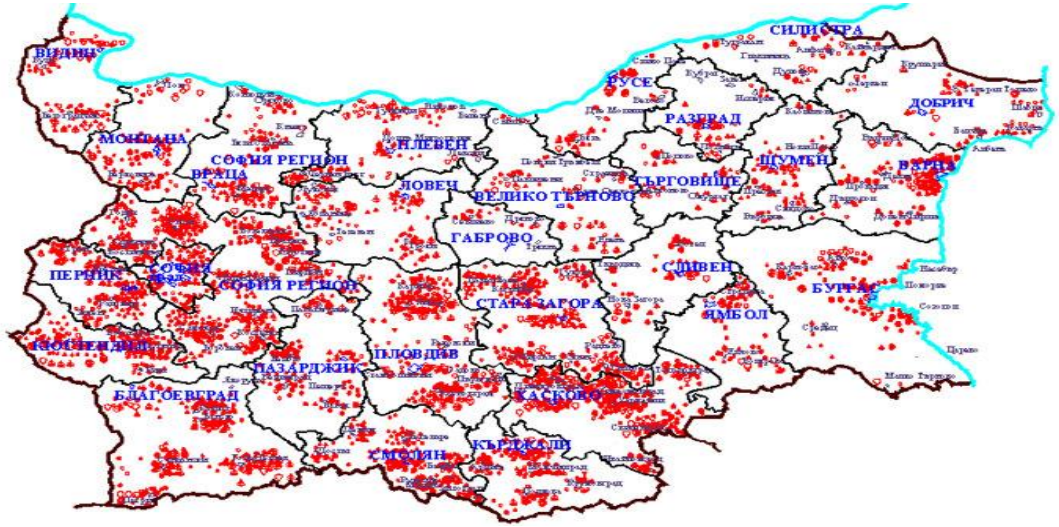
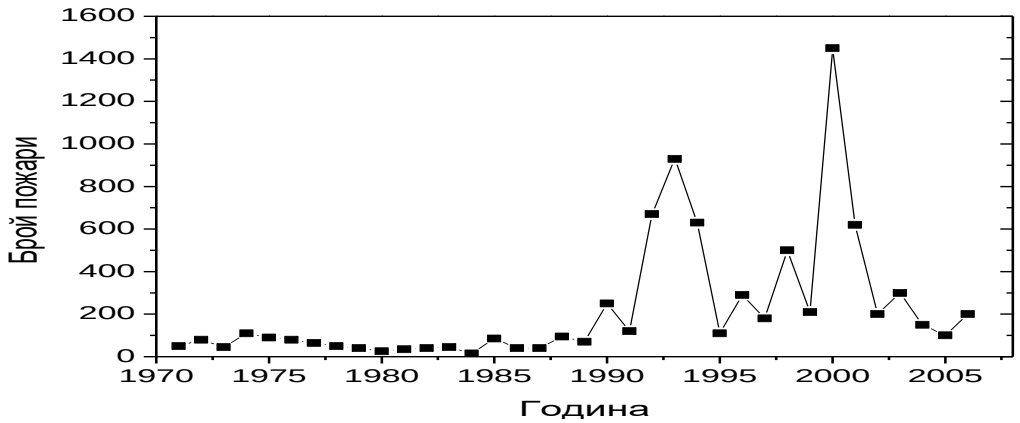
In this presentation …

1) Data availability for the test area of Zlatograd forestry area
2) FARSITE calibration
3) Simulations
4) Summary

Official forest fire's statistics for Bulgaria (1)

Based on annual report from Ministry of Agriculture, Food and Forests in BG for 2007





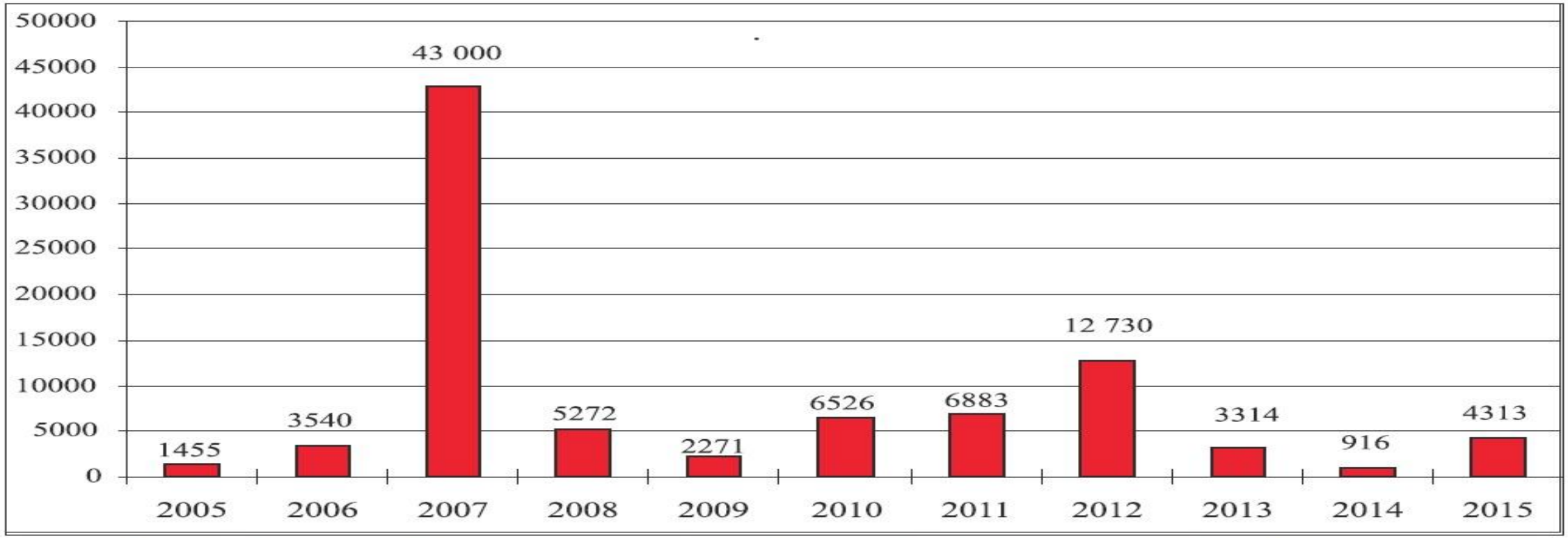
1994 to 2006

1971 to 2006

- considerable increase of the number of fires after 1990 (**more than 1000 fires in the year of 2000**)
- We do not know the burned area in ha

Official forest fire's statistics for Bulgaria (2)

Based on annual report from State Agency of Forests in BG for 2016



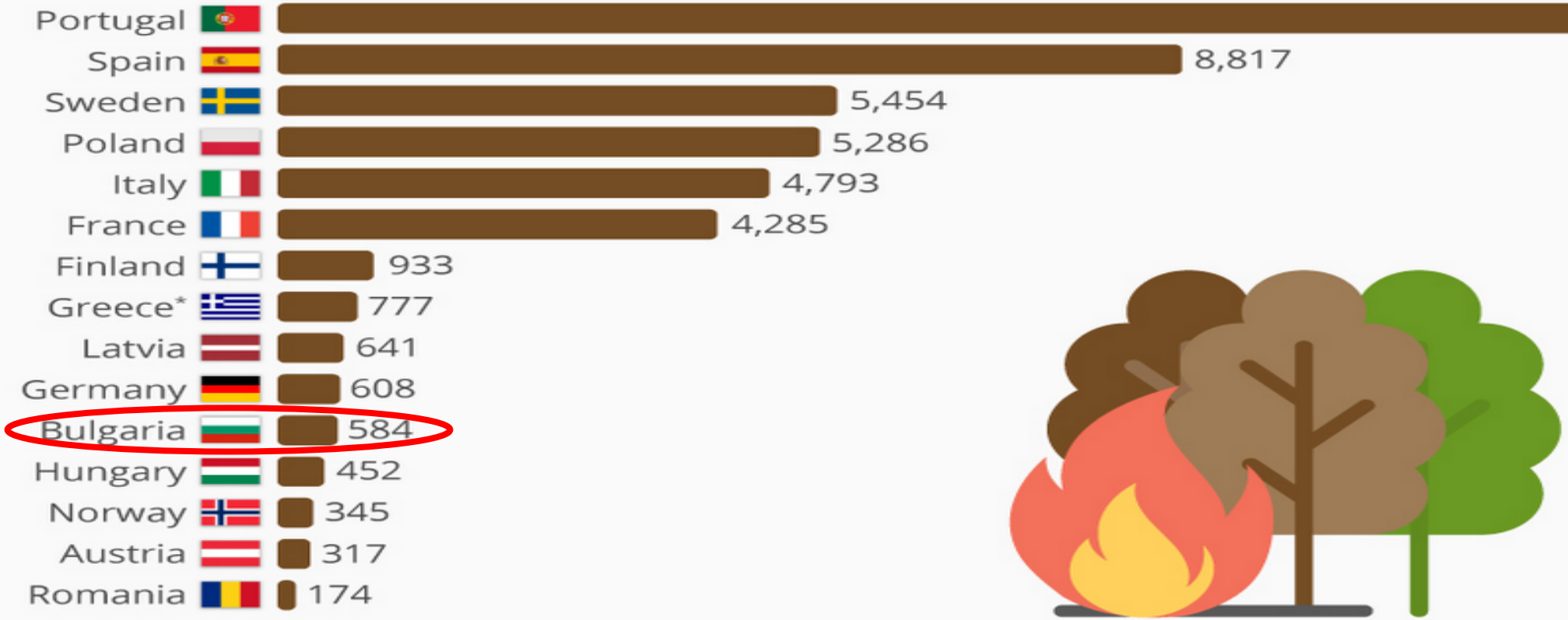
Опожарени горски територии (в ха) в България в периода 2005-2015 г.

Burned areas in Bulgaria (in ha) for the period 2005-2015

We do not know the number of fires behind this hectares

Forest Fires in Europe

Number of forest fires in selected European countries in 2016



* Estimate

Source: European Commission

statista

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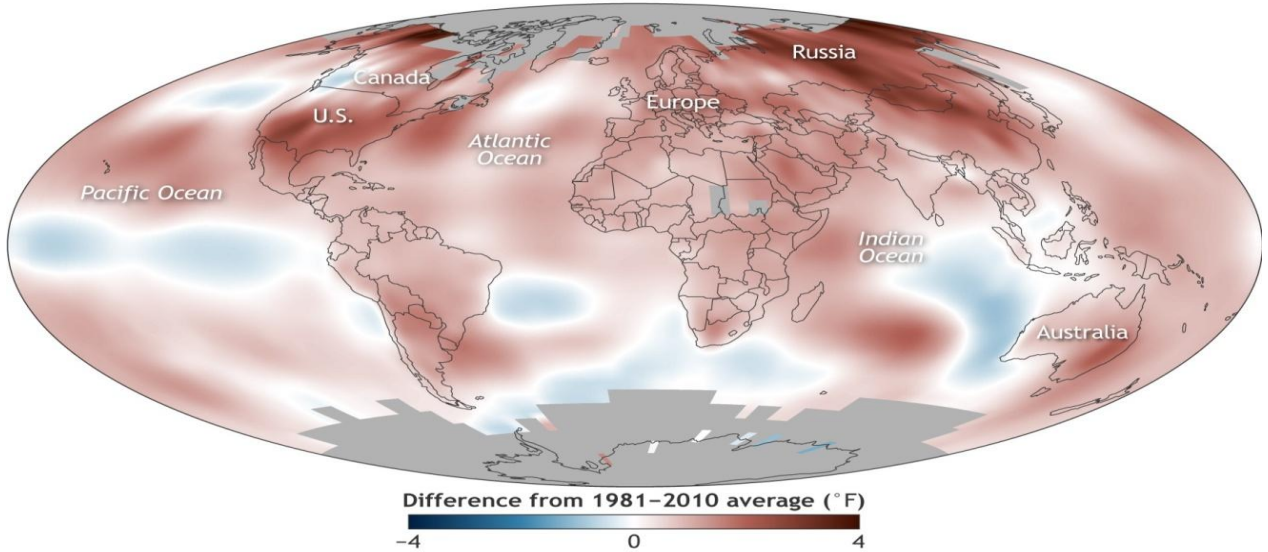
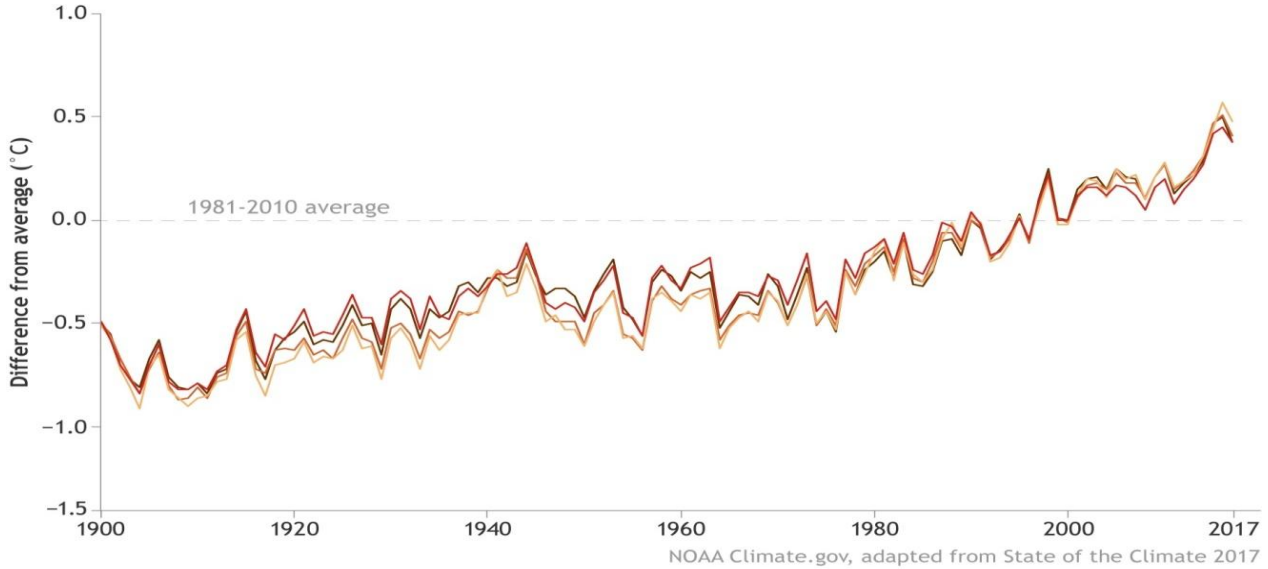
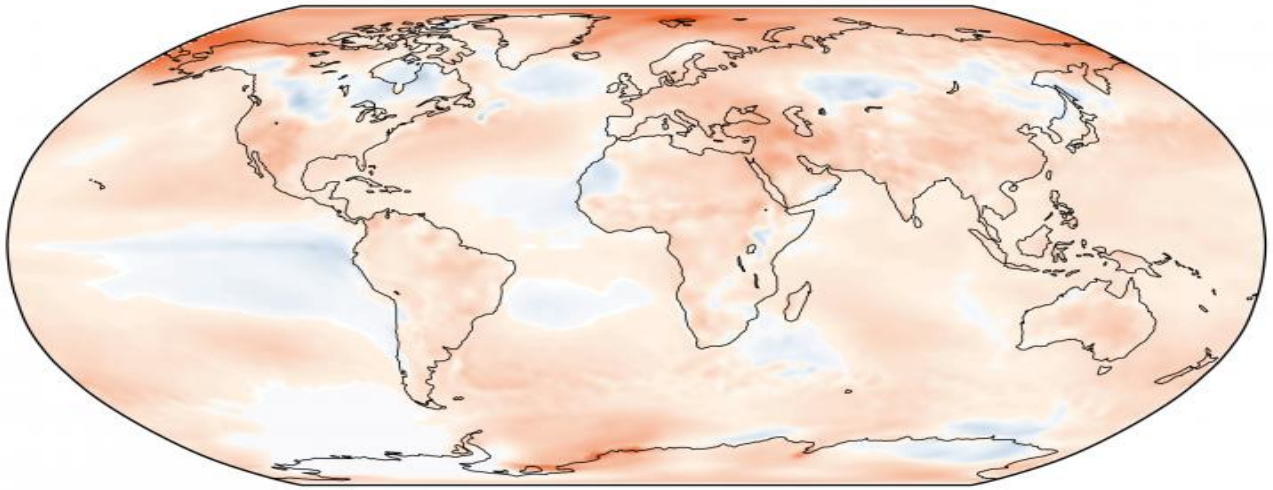
EXTREMELY WARM TEMPERATURES IN THE HIGH LATITUDES FOR 2017

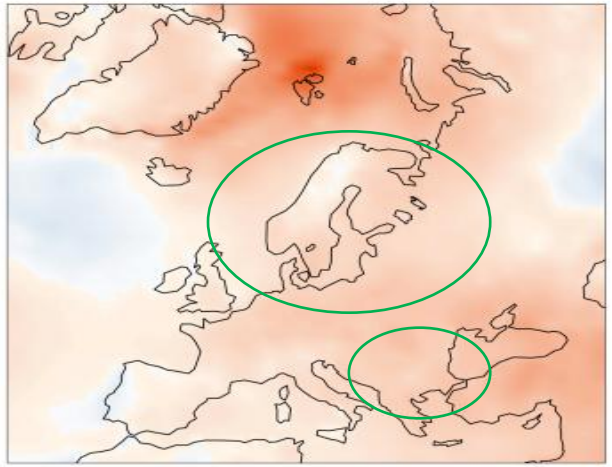


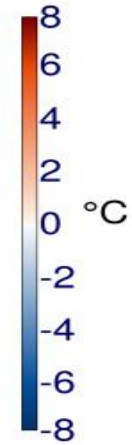
A SLIGHTLY COOLER 2017 IN THE ABSENCE OF EL NIÑO



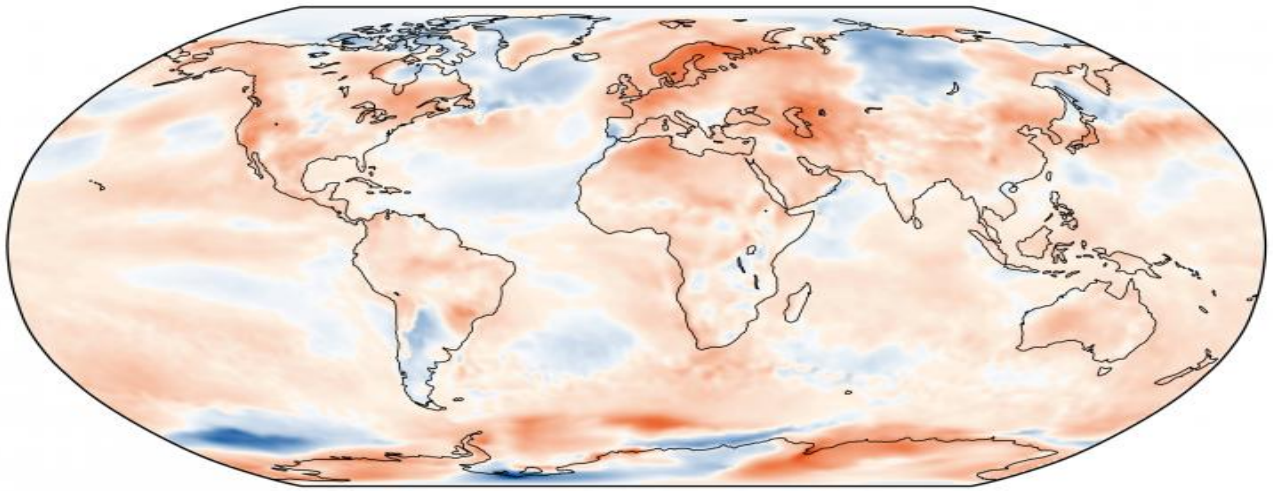
Surface air temperature anomaly for August 2017 to July 2018 relative to 1981-2010

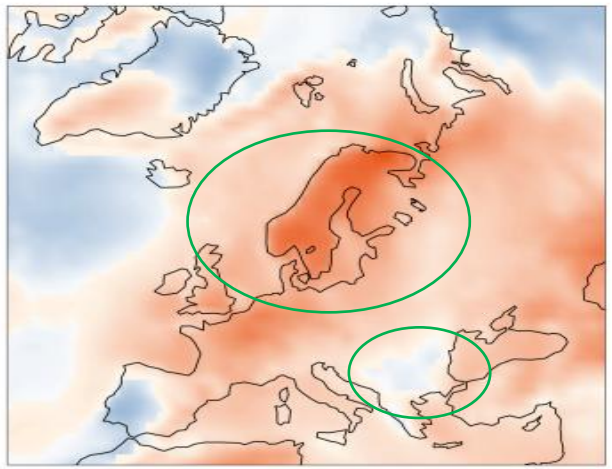


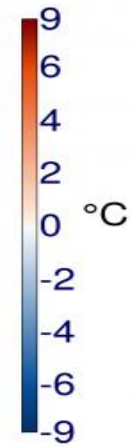




Surface air temperature anomaly for July 2018 relative to 1981-2010







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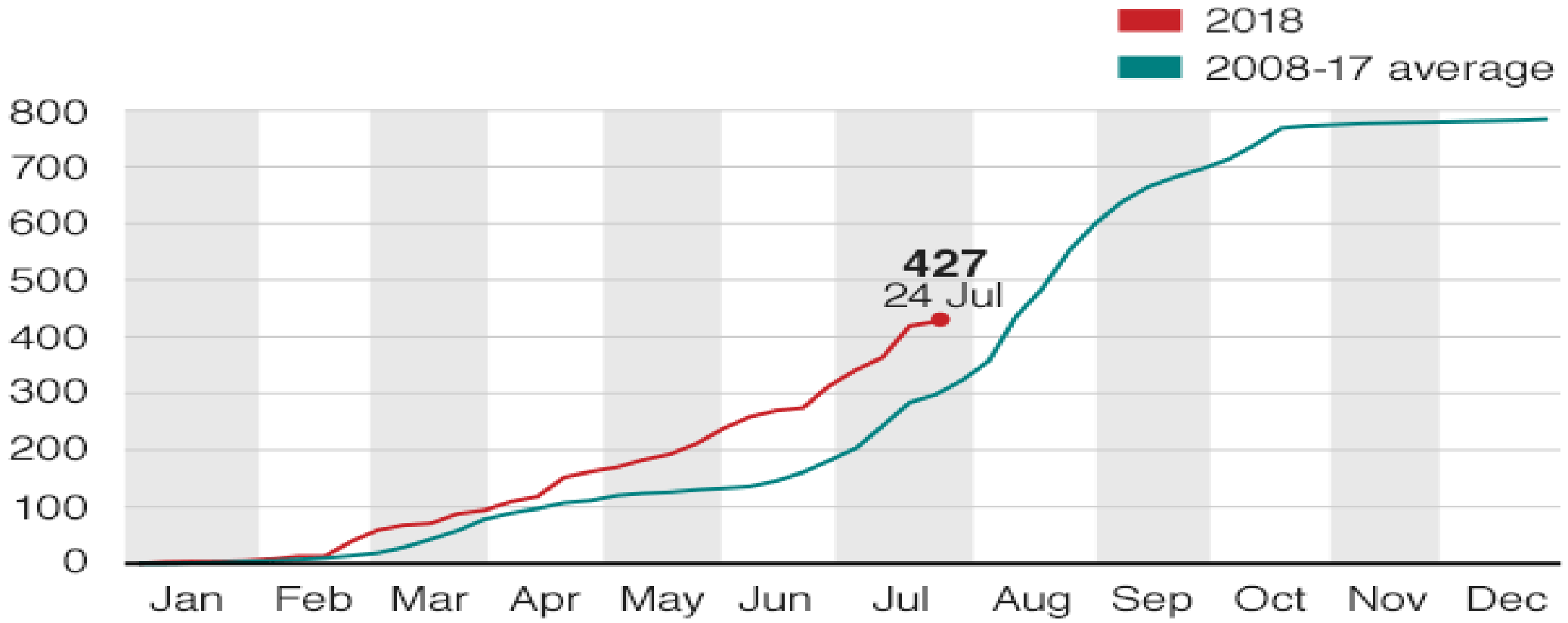
Average number of fires in EU countries

2008-17 average compared with 2018



Source: European Commission/Copernicus EMS/European Forest Fire Information System BBC

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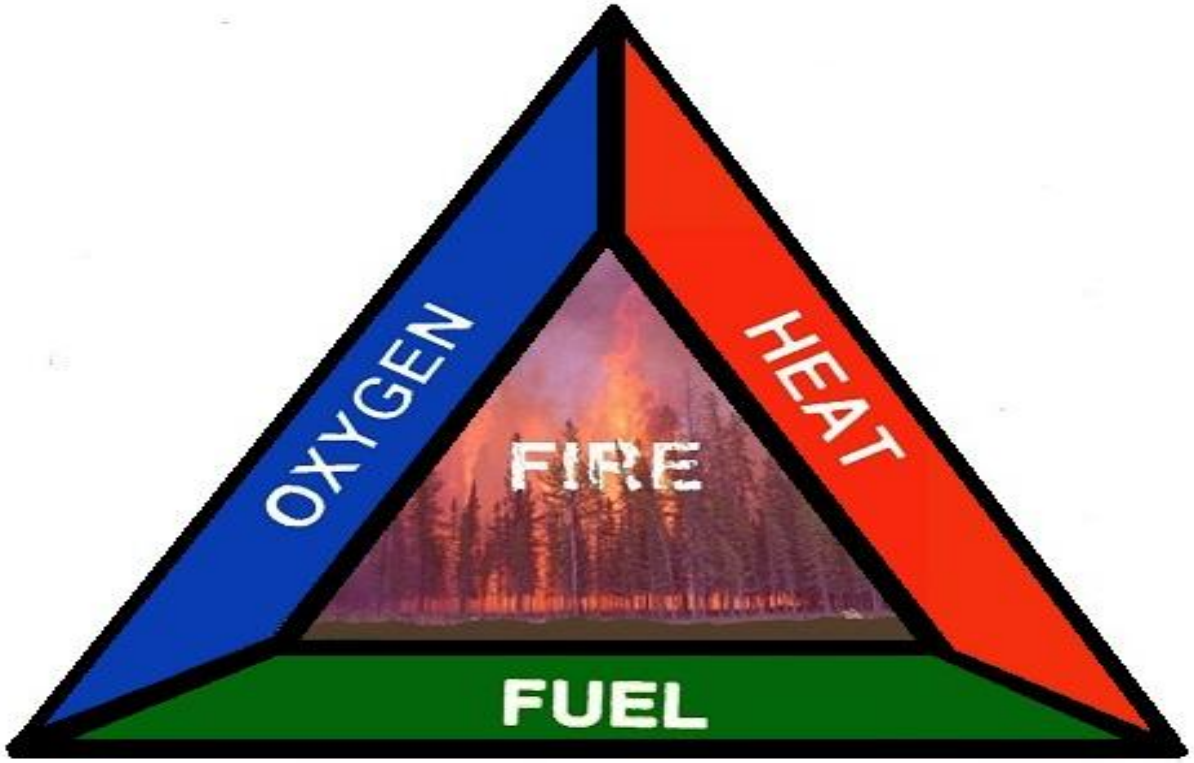
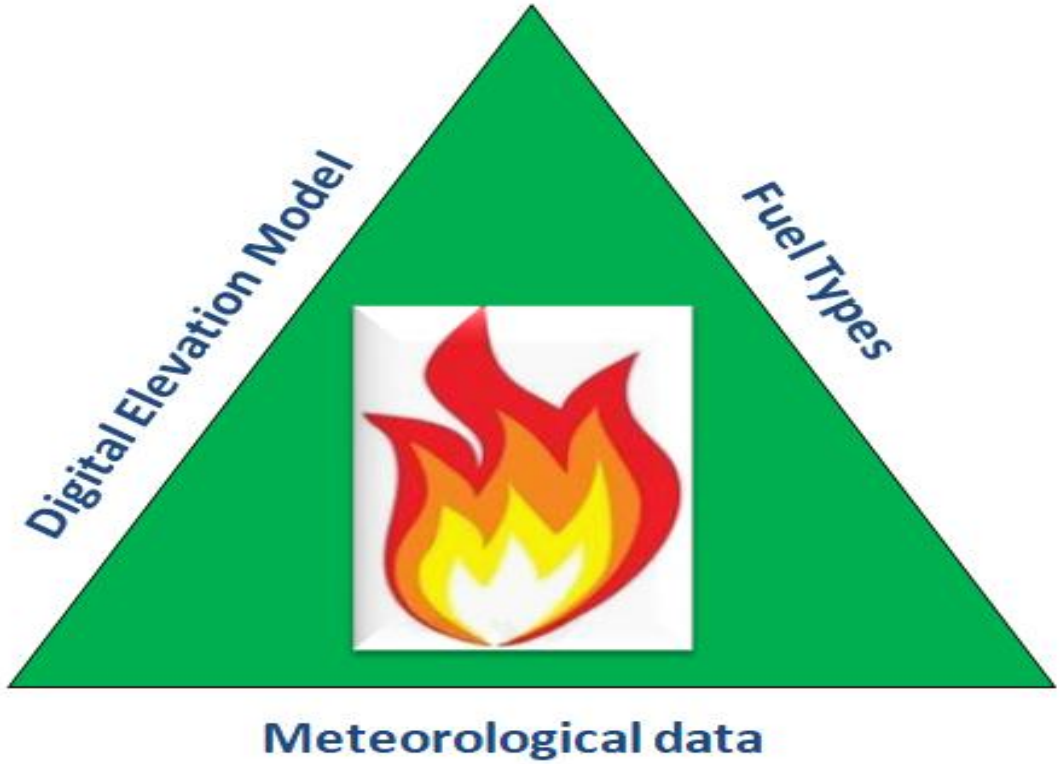
Wild Land Fires Nature



Simulation preparedness actions



Original Rothermel Formula - FARSITE

$$R = \frac{Heat\ Source}{Heat\ Sink} = \frac{I_{xig} + \int_{-\infty}^{0} \left(\frac{\partial I_z}{\partial z} \right)_{z_c} dx}{q_{be} Q_{ig}},$$

where:

- R – is parameter for re spread or the so called ROS(quasi-steady Rate Of Spread),
- I_{xig} – is the horizontal spread of the heat absorbed by the burning materials
- evaporating their water content,
- q_{be} – is the density of the burning materials which are heated until the re start,
- Q_{ig} – is the absorbed energy by the burning materials while they are evaporating
- their water content,
- $\frac{\partial I_z}{\partial z}$ – is the gradient of vertical intensity in the plane, where the energy is released.

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FARSITE – weather input

weather.wtr

Month	Day	Precip	Hour1	Hour2	Temp1	Temp2	Humid1	Humid2	Elevation	rt1	rt2
		L/m^2	UTC	UTC	tmin/0C	max/0C	max%	min%	m	UTC	UTC
12	9	56	2300	900	1	9	100	92	850	300	2300

- Precipitation is the daily rain amount specified in hundredths of an inch or millimeters (integer).
- Hour1 corresponds to the hour at which the minimum temperature was recorded (0-2400).
- Hour2 corresponds to the hour at which the maximum temperature was recorded (0-2400).
- Temperatures (Temp1 is minimum; Temp2 is maximum) are in degrees Fahrenheit or Celsius (integer).
- Humidities (Humid1 is maximum; Humid2 is minimum) are in percent, 0 to 99 (integer).
- Elevation is in feet or meters above sea level. NOTE: these units (feet or meters) do not have to be the same as the landscape elevation theme (integer).
- Precipitation Duration is optional with the beginning (rt1) and ending (rt2) times (0-2400) of the daily rain amount. Only one time period per day is allowed. If these fields are left blank the precipitation amount is assumed to be distributed

FARSITE – wind input

wind.wnd

Month	Day	Hour	Speed	Direction	CloudCover
		UTC	km/h	deg	%
12	9	300	23	167	100

- Hour is specified as 0-2359, to the nearest minute (integer).
- Speed is either the 20ft windspeed specified in miles per hour or the 10m windspeed in kilometers per hour (0-300, integer)
- Direction is specified in degrees, clockwise from north (0-360), (integer). A "-1" in the direction field indicates the winds to be up slope, similarly downslope winds can be specified with a "-2".
- CloudCover is specified as a percentage, 0 to 100 (integer).

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FARSITE – DEM, Aspect, Slope, Canopy Cover and Fuel Model inputs

File format ACII grid (ESRI format)

ncols 36

nrows 36

xllcorner 337098.21876909

yllcorner 4593900.8118804

cellsize 30

NODATA_value -9999

195 208 238 270 285 287 173 141 123 119 117 114 122 143 222 257 265 263 219 158 148 195 226 229 230 225 222 225 0 0 -9999 -9999 -9999 -9999 -9999

193 228 260 268 247 178 162 150 141 134 126 116 120 138 236 261 260 248 215 159 120 175 225 225 222 214 222 232 225 0 -9999 -9999 -9999 -9999 -9999

210 259 273 264 211 167 158 156 157 155 144 132 132 143 257 267 259 239 226 189 122 157 217 220 222 220 238 247 246 0 0 -9999 -9999 -9999 -9999

255 277 273 243 185 158 148 152 160 161 149 142 157 196 259 266 260 239 230 190 131 154 207 217 227 236 247 243 218 180 180 176 -9999 -9999 -9999

279 278 250 206 179 151 138 140 150 153 144 143 170 215 255 268 258 235 223 177 142 161 210 228 246 245 231 223 200 179 179 166 149 152 155 163

281 273 206 198 178 147 136 135 139 138 134 139 173 237 262 267 251 227 199 160 146 178 236 263 272 263 221 216 196 177 178 173 166 164 164 164

282 257 162 196 177 155 139 131 130 127 125 132 191 259 266 258 231 210 177 153 151 209 259 274 276 274 208 205 186 174 176 175 171 167 166 169

283 149 142 182 174 170 159 140 130 128 125 132 219 263 264 250 217 190 167 159 170 231 262 270 269 244 162 165 167 169 174 177 176 171 170 174

301 94 123 161 173 182 175 151 138 134 128 136 243 266 262 234 200 179 163 164 197 250 263 264 253 195 163 159 157 163 172 177 178 177 177 177

Collected data

1. The DEM

2. The meteorology in the required formats

3. The fuel types had been developed for the purposes of OUTLAND project

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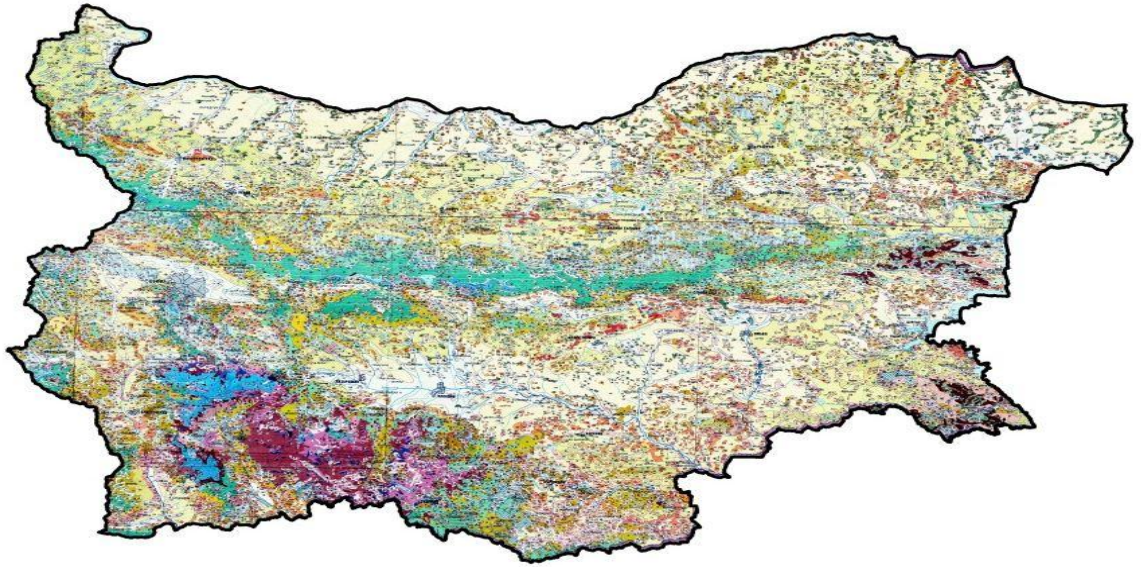
We started with the Vegetation paper map of Bondev since 1991 as base Bulgarian vegetation types in TIF format



Then we cut the border of the Zlatograd forestry department area, which was our shape template for the GIS layers

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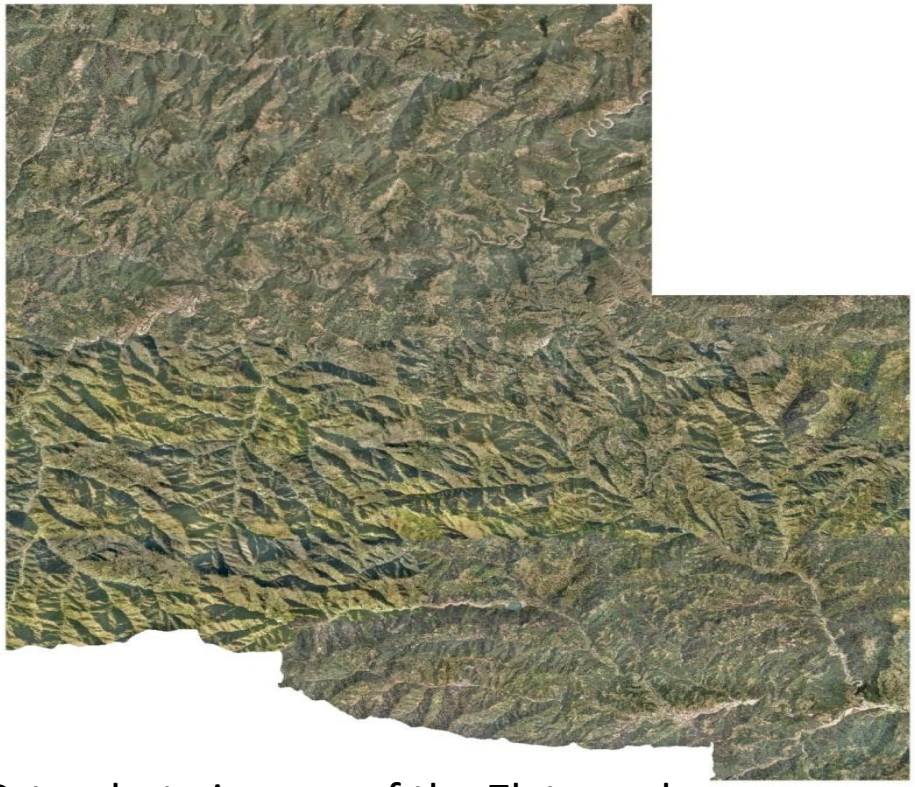
We had to get also satellite and orto-photo images in UTM-WGS84 projection in order to have idea of the canopy cover and land use

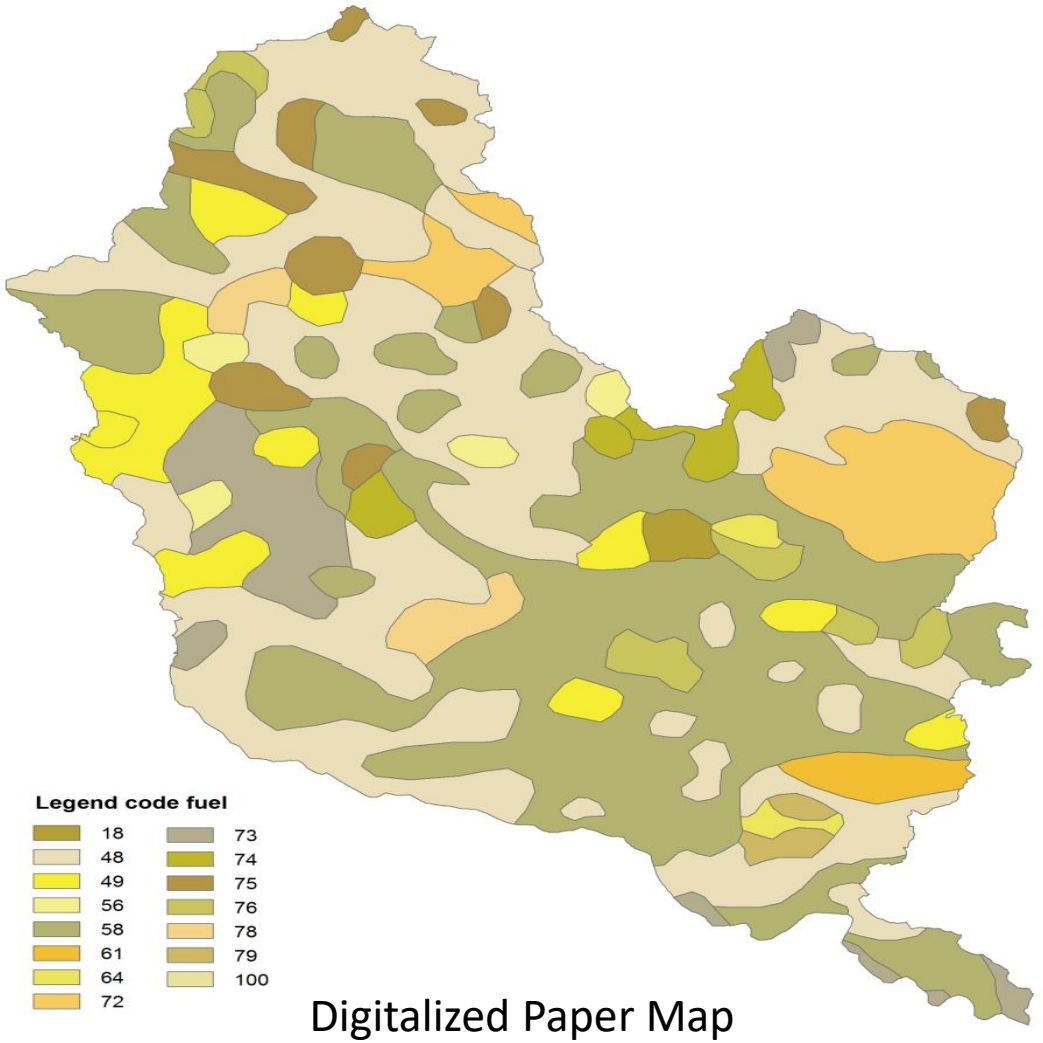
Satellite images of the Zlatograd forestry department area



Orto-photo images of the Zlatograd forestry department area

Vegetation Map of Zlatograd area Bondev (1991)

Paper Map



Digitalized Paper Map

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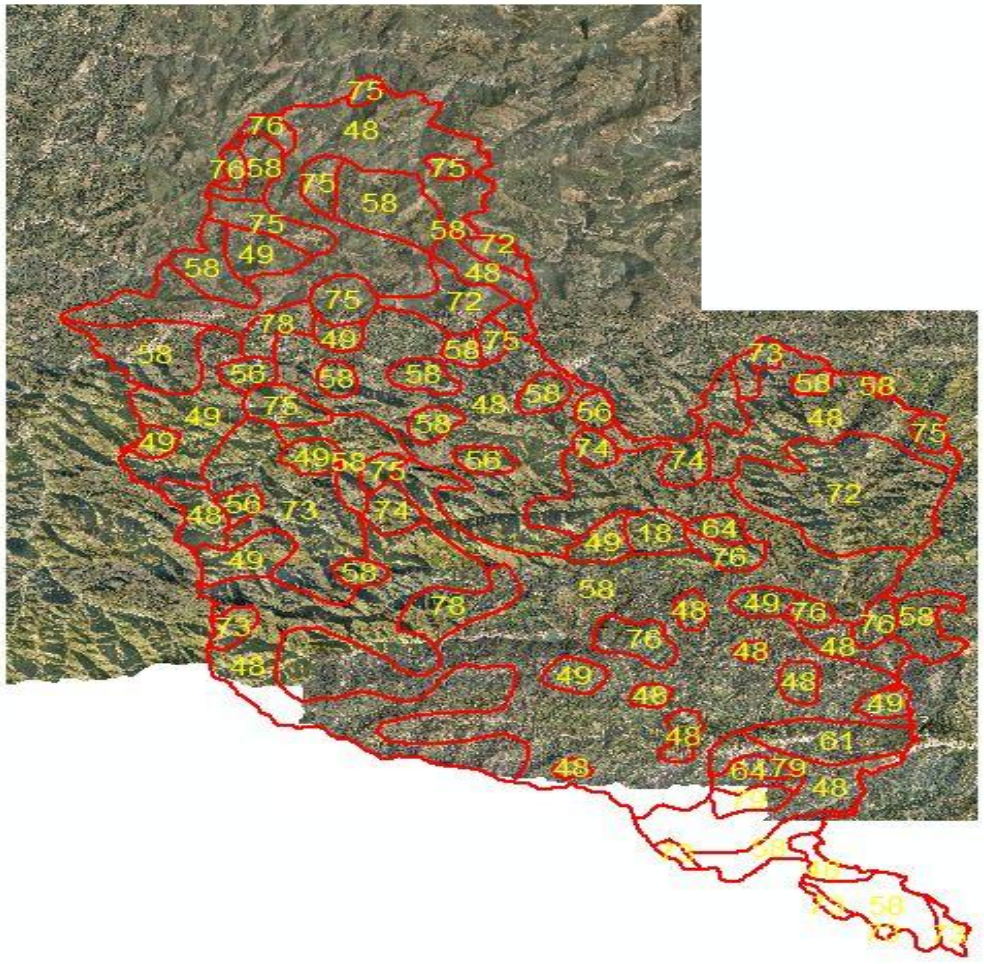
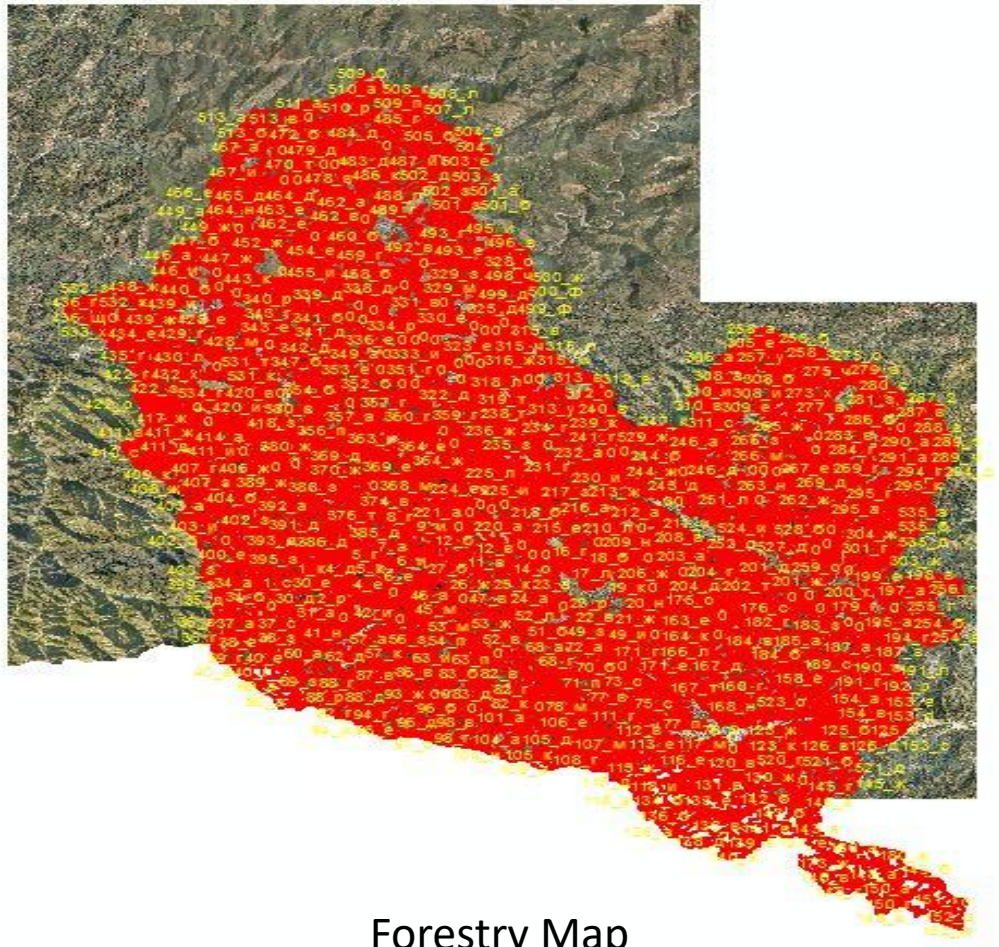
Comparison of Bondev (1991) vegetation map and Forestry Map



Bondev Digital Map



Forestry Map

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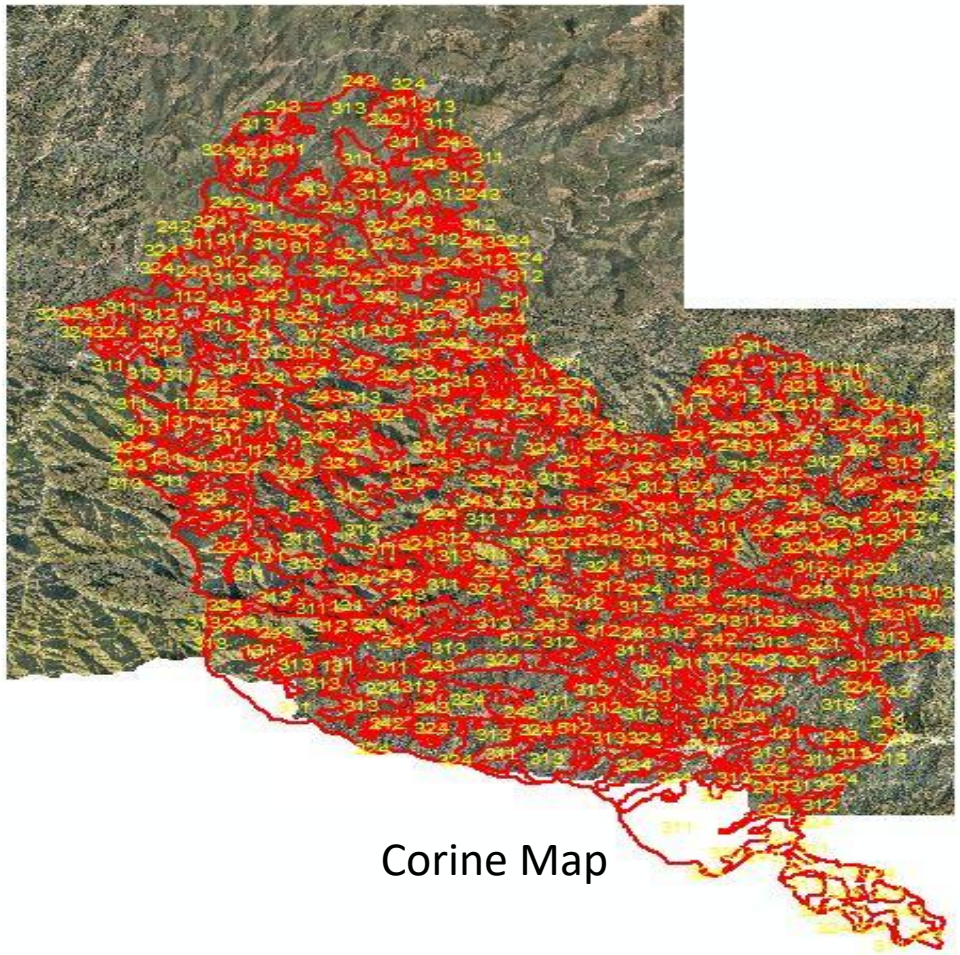
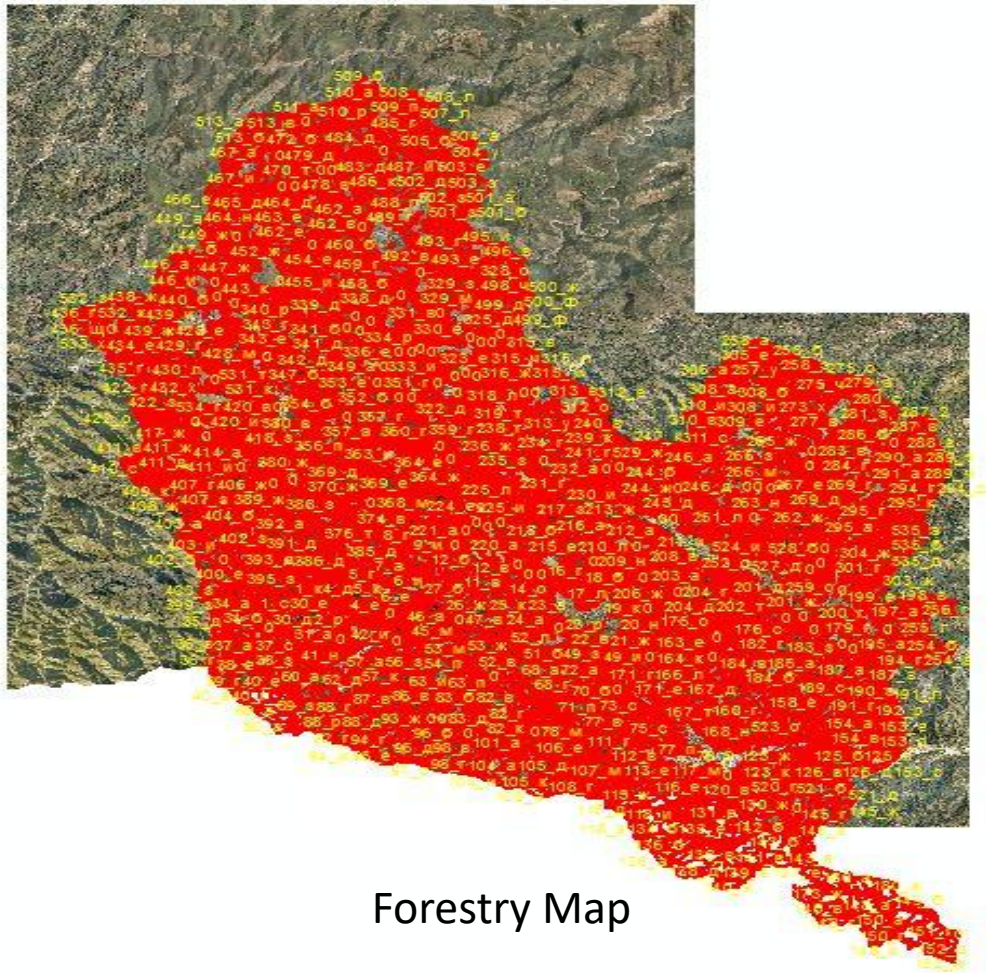
Comparison of Forestry and Corine vegetation maps for Zlatograd Areas

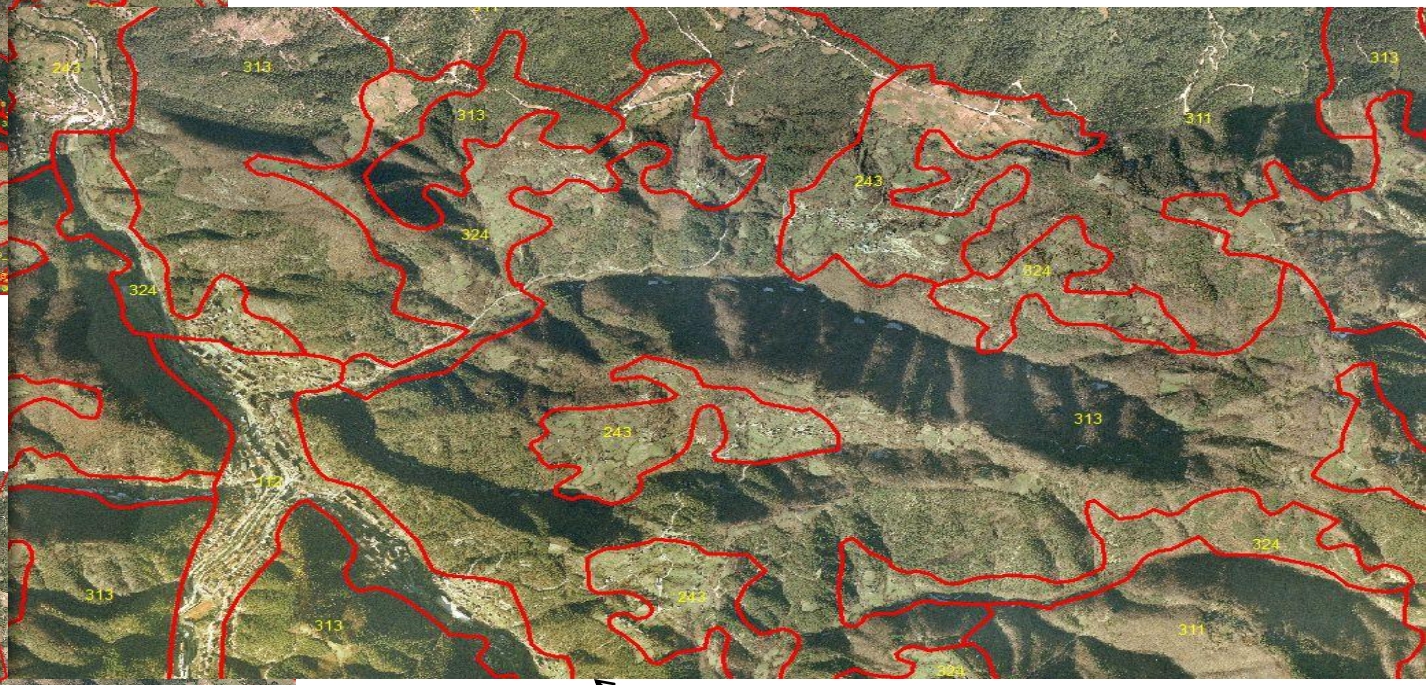


Corine Map



Forestry Map

Forestry map fragment



Bondev map fragment

Corine map fragment

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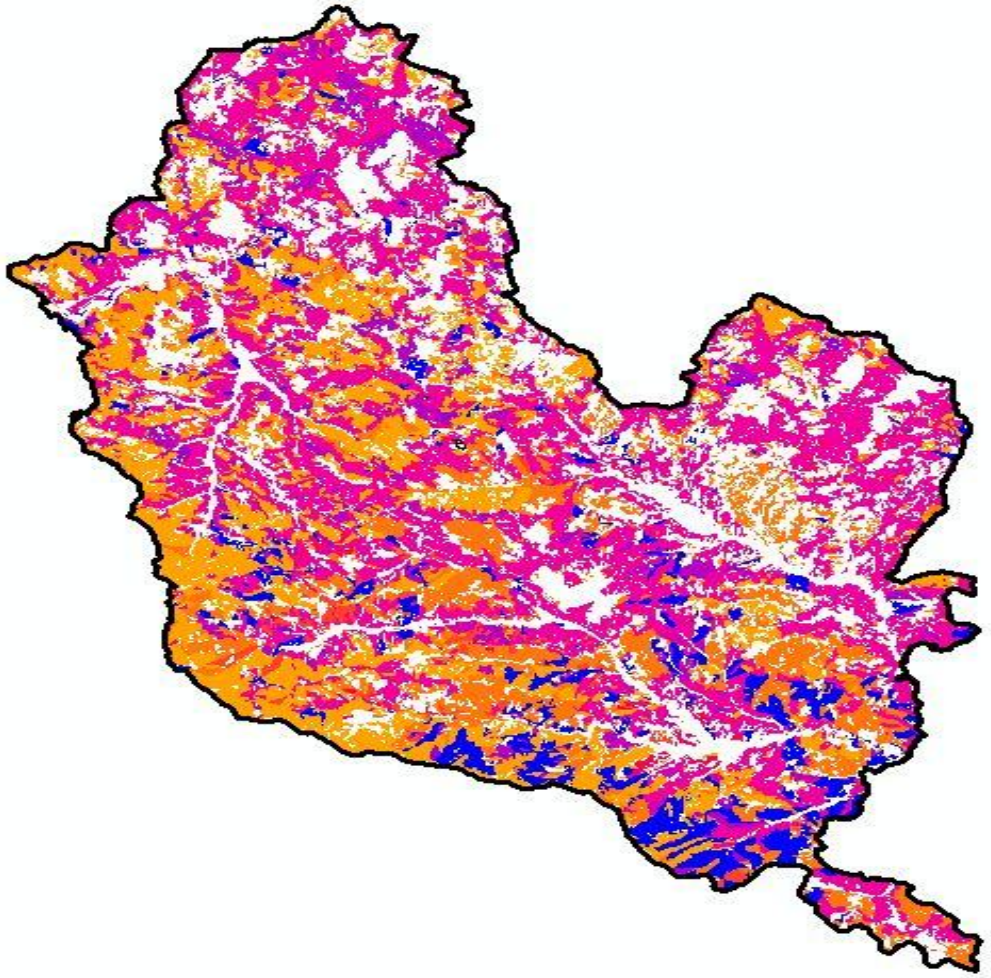
We tried to use directly the EUNIS classification available for EUROPE



- G1.131 Southern black alder galleries
- G1.69 Moesian [Fagus] forests
- G1.69 Moesian [Fagus] forests GF.4 Mixed fore
- G1.76 Balkano-Anatolian thermophilous oak fo
- G1.7C1 Hop-hornbeam woods
- G1.7C2 Oriental hornbeam woods
- G1.92 Aspen woodland
- G1.A32 Eastern hornbeam woodland
- G1.C3 [Robinia] plantations
- G1.C4 Other broadleaved deciduous plantations
- G1.F11 Native fir spruce larch cedar plantation
- G3.16 Moesian silver fir forests
- G3.F12 Native pine plantations
- G3.F21 Exotic spruce fir larch douglas fir deo
- G4.5 Mixed Scots pine - beech woodland
- G5.61 Deciduous scrub woodland
- G5.7 Coppice and early-stage plantations
- GF.4 Mixed forestry plantations

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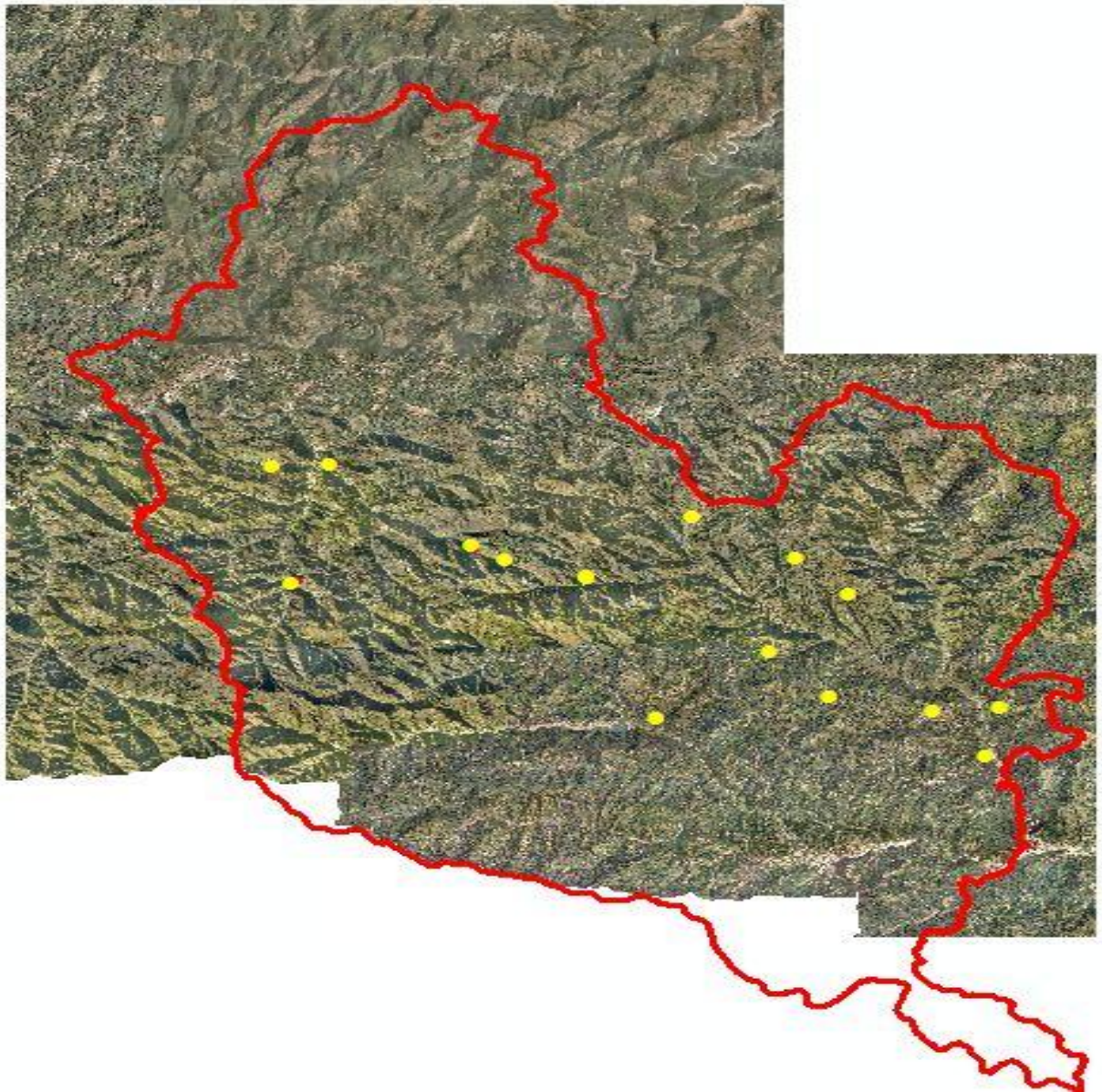
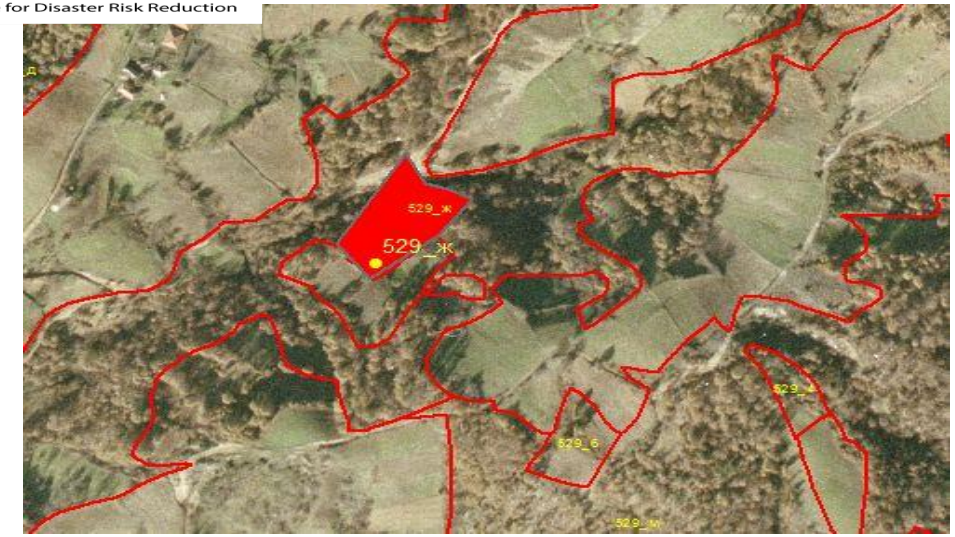
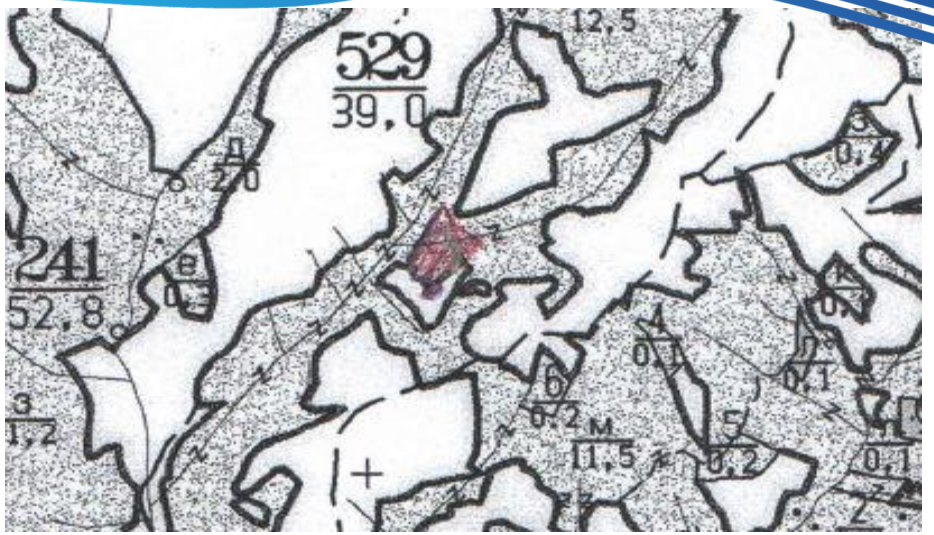
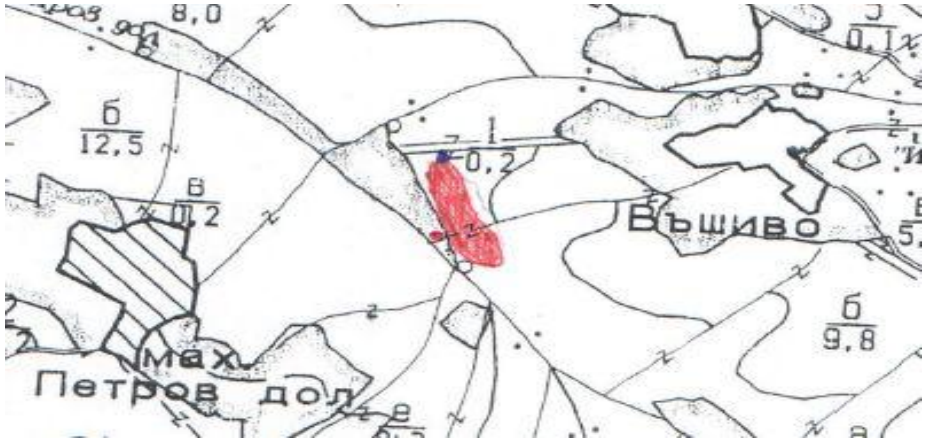


15 test cases of Zlatograd forestry department for the years 2011 and 2012

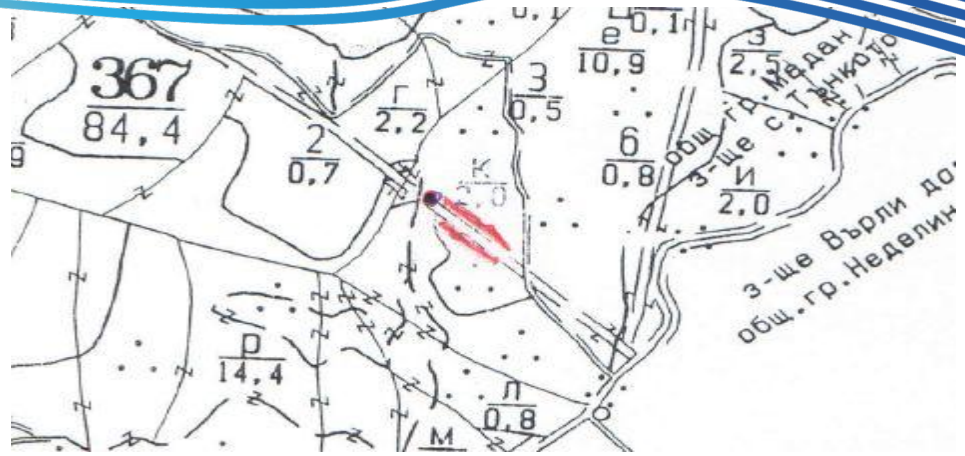




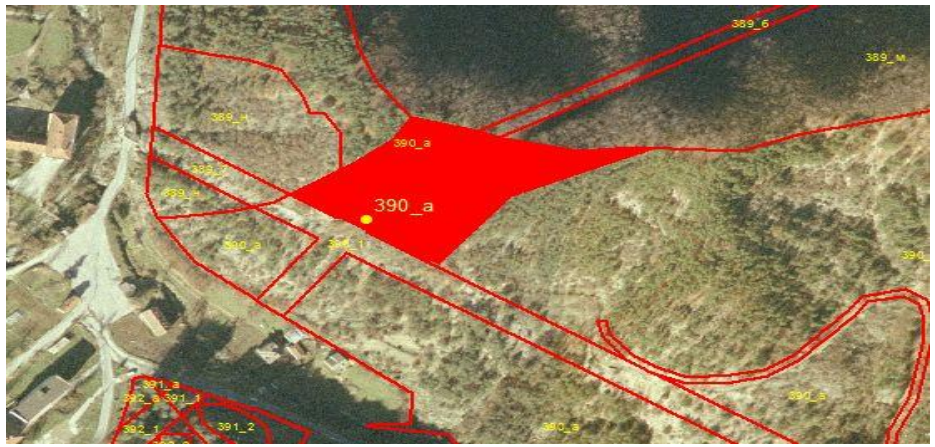
Fire N 1 - section 529 subsection – ж.

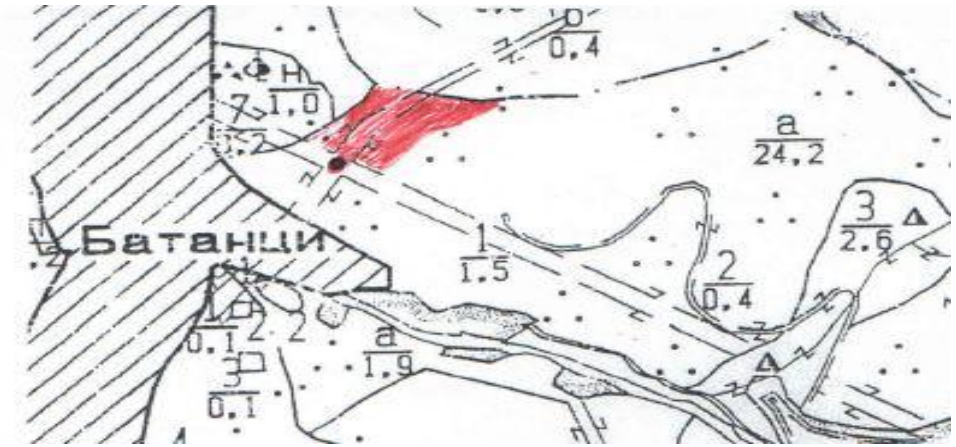


Fire N 2 - section 367 subsection - а.

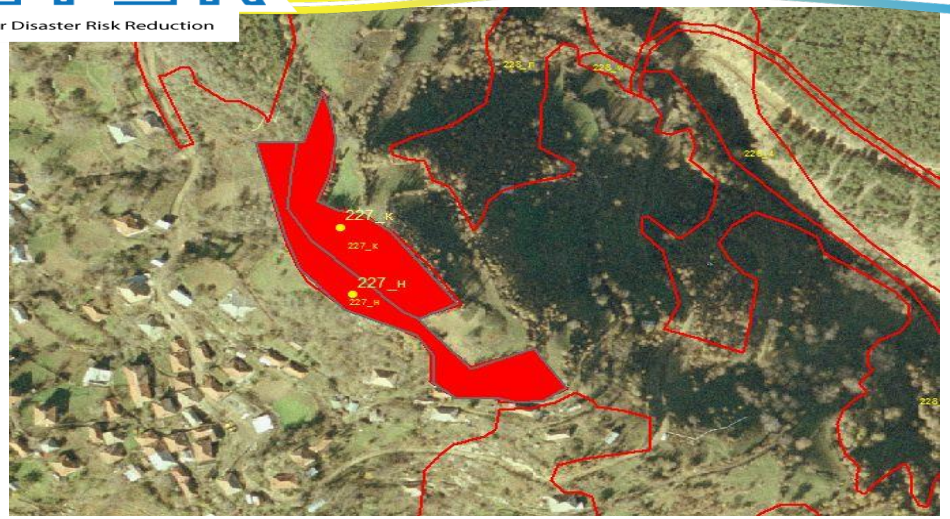


Fire N 3 - section 367 subsection – к.

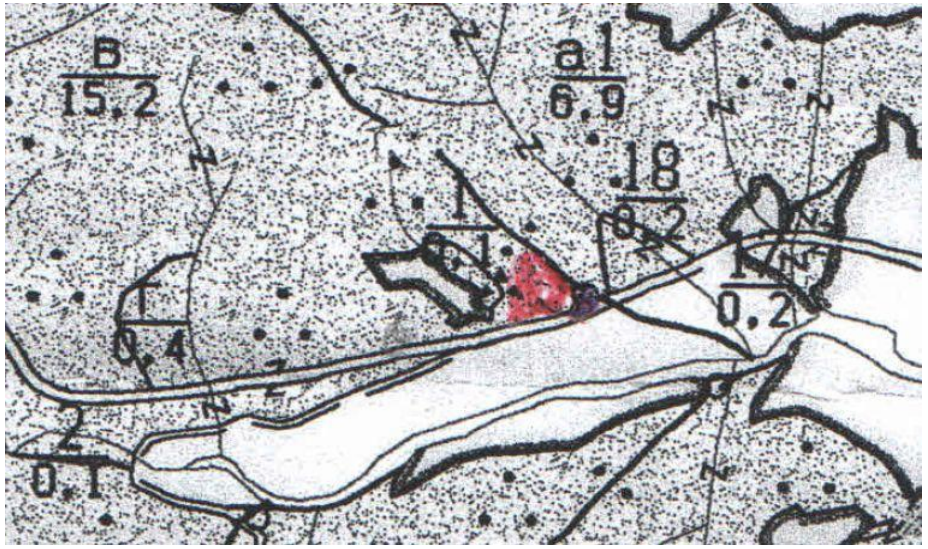




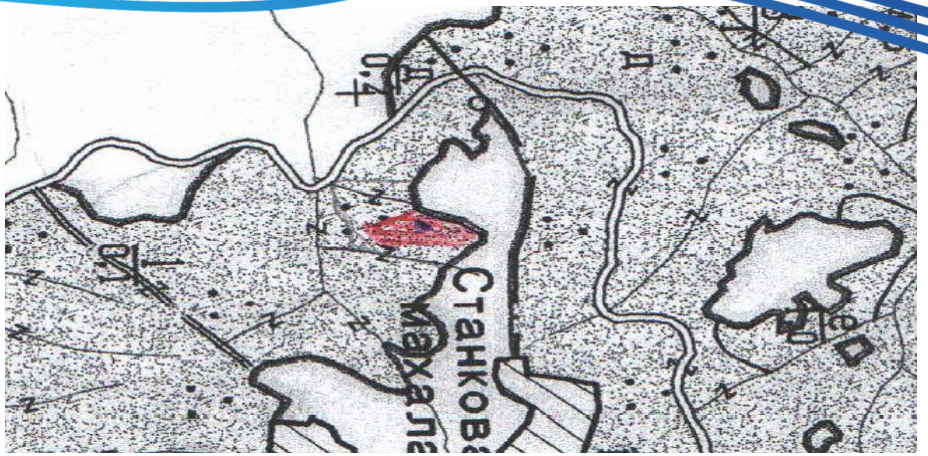
Fire N 4 - section 390 subsection - а.



Fire N 5 - section 227 subsection – а & к

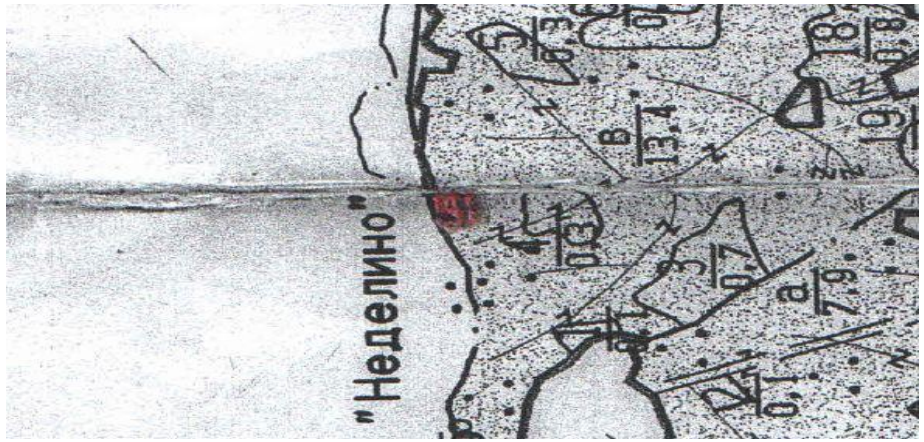


Fire N 6 - section 206 subsection – в.

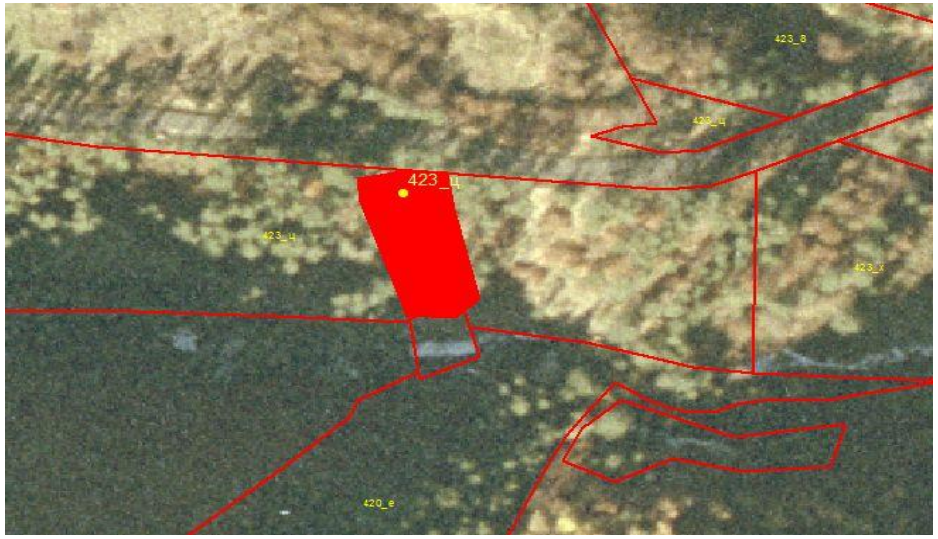


Fire N 7- section 196 subsection –a

Fire N 8- section 356 subsection - б.

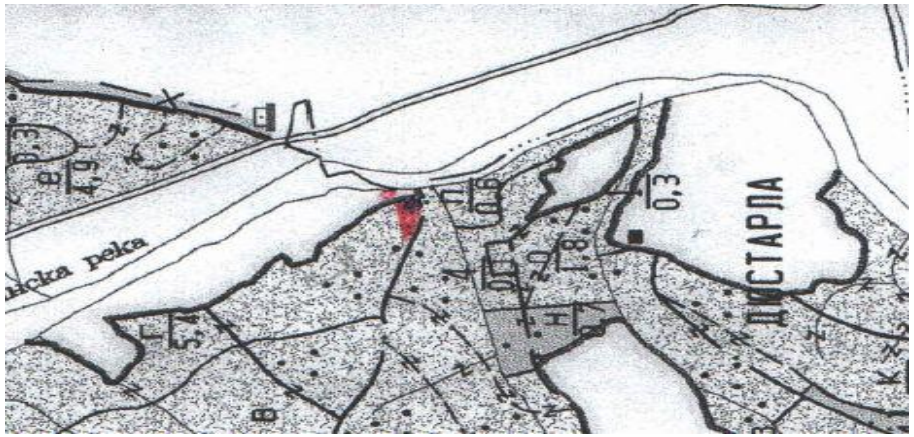


Fire N 9 - section 179 subsection– в

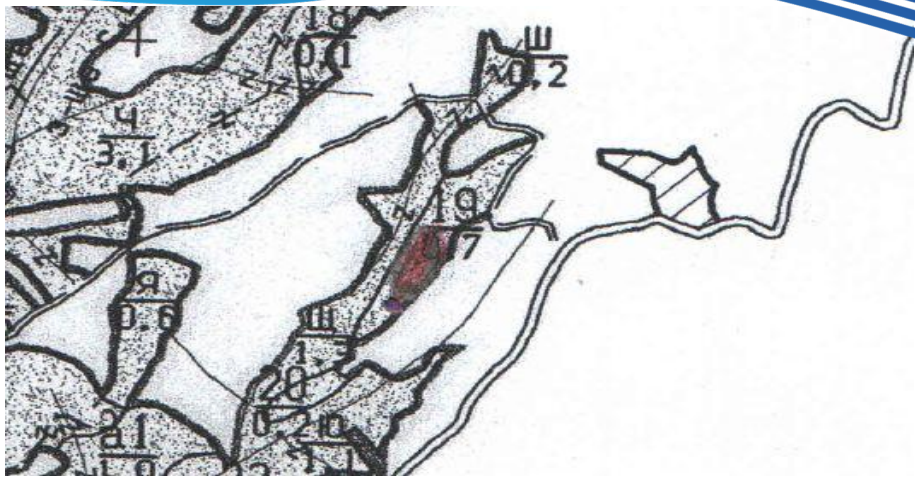


Fire N 10 - section 423 subsection - ц.

Fire N 11 - section 250 subsection – п.

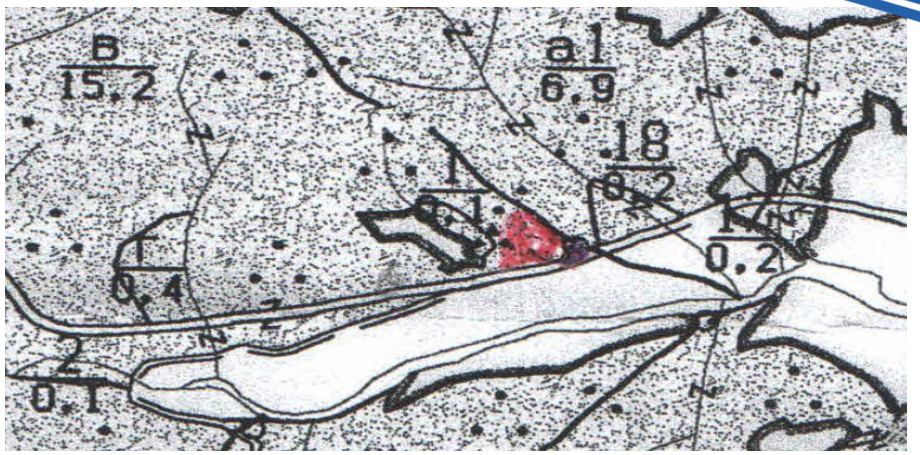


Fire N 12 - section 187 subsection – г



Fire N 13 - section 525 subsection – 19.

Fire N 14 – section 177 subsection – к



Fire N 15 – section 23 subsection – p

With this digitalized shapes we could get the starting point of the fires and also the burned area and shape of the final area damaged by the fire.

Fire No.	Vegetation type	Burned area in decares	Date of occurrence	Hour of start	Hour of end
1	Durmast	3.0	25 March 2012	1330	1530
2	Beechwood	5.0	29 March 2012	1400	1800
3	Scotch pine	1.0	16 June 2012	1500	1700
4	Scotch pine	7.0	6Aug. 2012	1640	1950
5	Scotch pine	5.0	6 Aug. 2012	1710	2130
6	European black pine	4.0	27Aug. 2012	1200	1600
7	Scotch pine	3.0	5 Sept. 2012	1400	2030
8	Scotch pine	6.0	6 Sept. 2012	1400	1930
9	Scotch pine	2.0	6 Oct. 2012	1600	2320
10	Scotch pine	1.0	16 March 2011	1310	1400
11	Scotch pine	1.0	5 April 2011	1715	1900
12	Scotch pine	1.0	10 April 2011	1130	1530
13	Grassland	3.0	30 Aug. 2011	1400	1800
14	Scotch pine	4.0	12 Sept. 2011	1230	1900
15	Scotch pine	1.0	15 Sept. 2011	1600	1830

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Custom FUEL Model representative

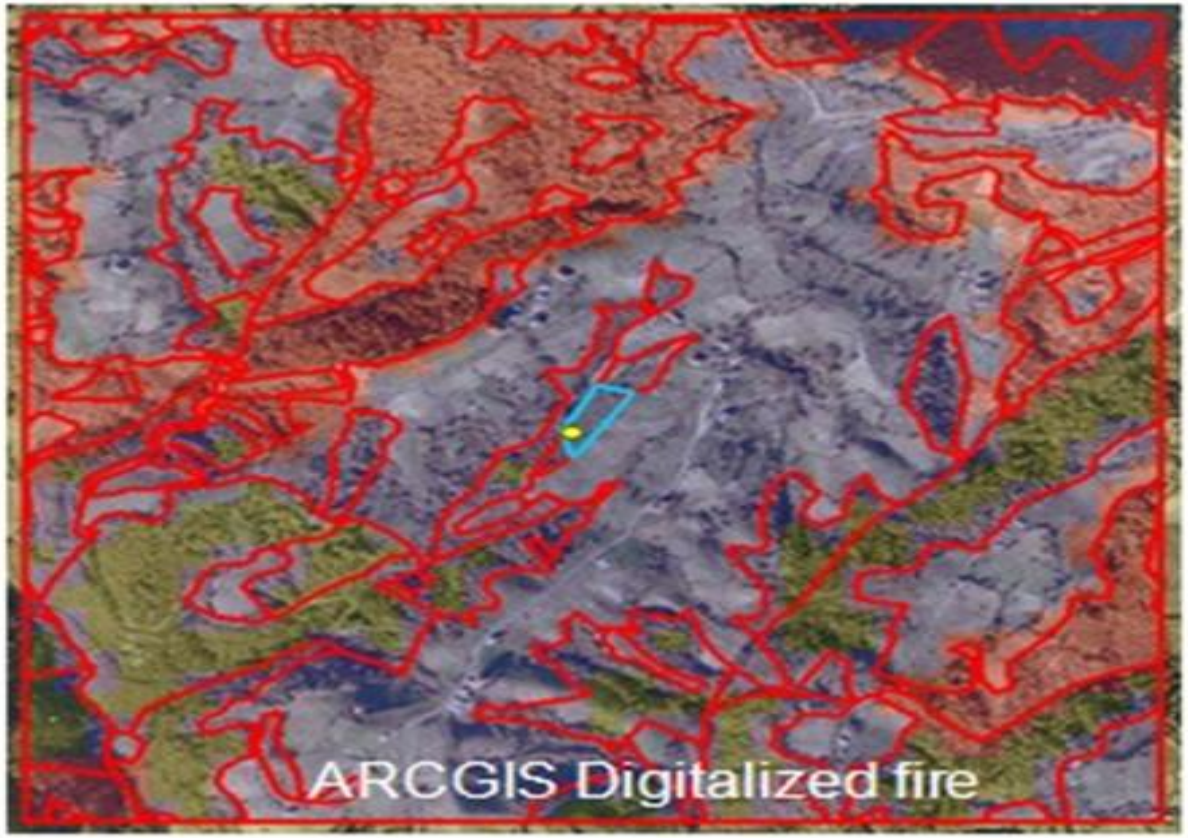
As an example of one of our successful FARSITE runs, we present the results from a single wildfire that burned in grassland vegetation, for which we developed custom fuel models. This fire occurred on August 30, 2011, starting at 1400 and ending around 1800, and burned a total area of 0.3 ha.

We used the following input parameters to model this small grassland fire in FARSITE:

Fuel moisture values: 6% (1-hr), 7% (10-hr), 9% (100-hr),
45% (live herbaceous) and 75% (live woody);
Daily maximum temperatures: 17-21°C;
Daily minimum relative humidity: 24-50%;
Winds: generally from the west-southwest at 1-2 k h^{-1}

The fire size as calculated using FARSITE was 0.5 ha, which seems reasonable considering the modeled size would not have included the suppression actions that most likely occurred given the close proximity of a village to this fire.

FARSITE RUN with Custom FBFM



Picture : FARSITE run with grassland fire

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Standard FUEL Model representative

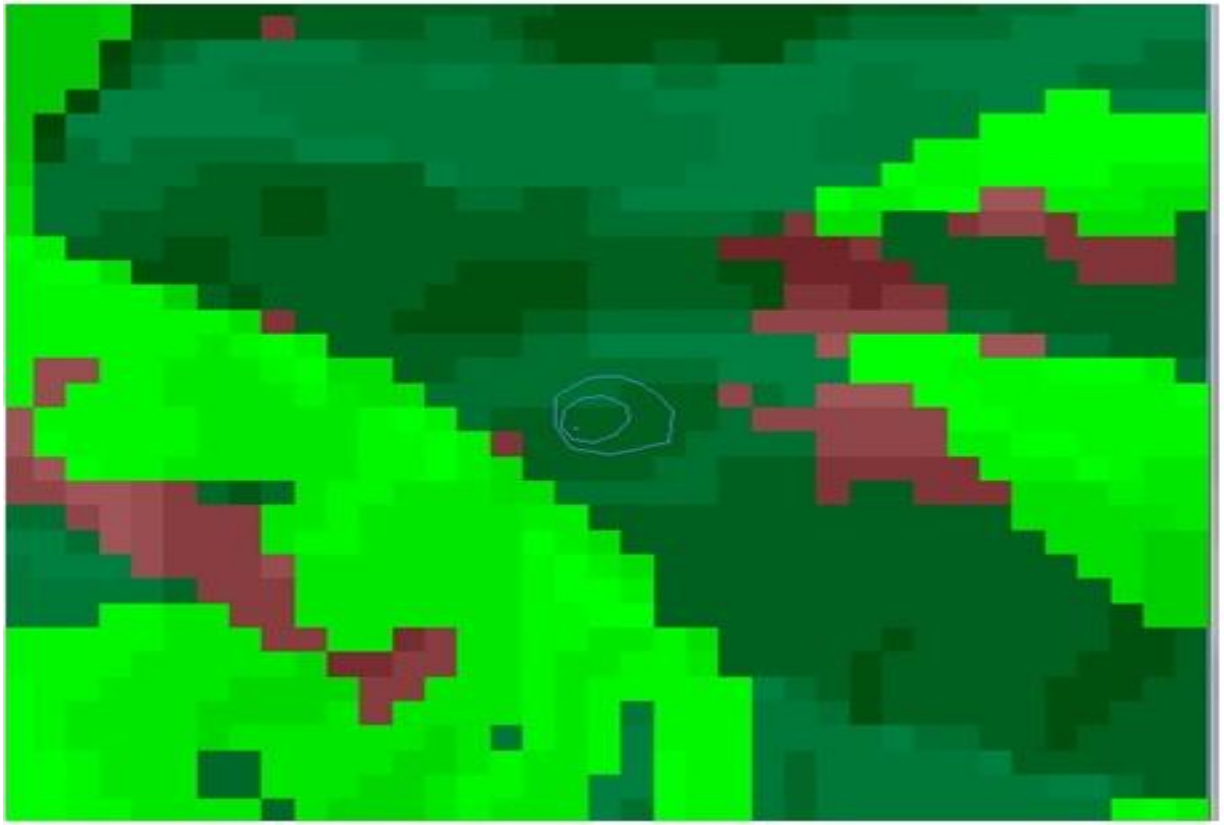
An example of another fire we modeled in FARSITE using standard fuel models was a fire that occurred on March 29, 2012 in a beechwood forest. This fire burned for a total of four hours, starting at 1400 and ending around 1800, and burned a total area of 0.5 ha. Wind speeds were variable throughout the burning period as they were quite high during the early afternoon but tapered off throughout the day.

In this case we used the following input parameters in FARSITE:

Fuel moisture values: 3% (1-hr), 4% (10-hr), 5% (100-hr),
40% (live herbaceous) and 70% (live woody);
Daily maximum temperatures: 7-10°C;
Daily minimum relative humidity: 36-40%;
Winds: generally from the north-northeast at 10-2 k h^{-1}

The projected fire size from FARSITE was 0.9 ha. Based on the close proximity of a village to the fire location it is quite reasonable to assume that local residents responded to the fire in a volunteer capacity; these suppression actions are not accounted for in the FARSITE analysis. Decreasing winds through the afternoon may have significantly helped suppression activities.

FARSITE RUN with Standard FBFM



FARSITE run for wildfire that burned in a beechwood forest

Conclusions

Vegetation Type	Possible Fuel Models	Logic/Assumptions
Scots pine (*Pinus sylvestris*)	188 (often used for ponderosa pine) 183 – modified	Ponderosa pine (*Pinus ponderosa*) may be a suitable western US proxy. Otherwise, probably a modified 183 (TL3) to increase rate of spread and flame lengths.
Black pine/Acacia (*Pinus nigra*/*Acacia*)	161 183 – probably modified	FBFM 161 works best when the understory is dominated by an herbaceous understory including forbs and grasses (it is dynamic). Creating a custom fuel model starting from FBFM 183 is another solution, to increase the rate of spread and flame lengths. Using FBFM 165 would assume ladder fuels to be present and will probably overpredict rate of spread and flame lengths.
Beechwood (*Fagus sylvatica*)	182/186 (dormant season fire) 161 (growing season fire)	FBFM 182 or 186 (or a custom FBFM) may be used when a fire is mostly burning through hardwood (round leaf) litter. FBFM 186 tends to have much higher rate of spread and flame lengths than 182. FBFM 161 is dynamic and may be used during the growing season when a fire would be expected to burn through the understory vegetation.
Durmast (*Quercus dalechampii*)	182/186 (dormant season fire) 161 (growing season fire)	FBFM 182 or 186 (or a custom FBFM) may be used when a fire is mostly burning through hardwood (round leaf) litter. FBFM 186 tends to have much higher rate of spread and flame lengths than 182. FBFM 161 is dynamic and may be used during the growing season when a fire would be expected to burn through the understory vegetation.
Grasslands	101 (may be best for grazed pasture) 102 (ungrazed pasture) Custom FBFM (lower ROS and FL than FBFM 101)	Assumes no irrigation. Rate of spread and flame length drastically change depending on chosen FBFM.

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Thank you!

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