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Forest Fire Prevention and Suppression Using Optimum Routes and Speeds of Firefighting Vehicles: Case Study the Peri-Urban Forest of Thessaloniki, Greece

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Abstract: *Fire is a frightening element and to be involved in a wild forest fire out of control is an experience that few people would want to relive. All countries are not faced with an equal potential of forest destruction and human tragedy such as Mati Greece; some, indeed, are fortunate enough to have practically no area of risk. The fact that great losses have not as yet occurred in other countries is no reason for assuming that they can not happen. Forest fire prevention and on second course suppression is the number one objective goal for Civil Protection Officers at the summer period especialy when that is expanded between the end of spring and the beginning of autum. The peri-urban forest of Thessaloniki was chosen because it is directly adjacent to the town complex and at the same time there are some properties that are at times sites of forest fire. The aim of our research based on As Forest Engineerers we know that the answer might be easy by using forest infrastructure and optimazating the road network. The problem we spoted is the transfer of Forest Service knowledge and know-how to the Fire Department. Unfortunately, the small number of Forest Service graduates is not sufficient to organize large-scale forest fires especially when mechanical means are inadequate for movement in the forest and firefighters do not have the necessary firefighters. We used open access program of Google in order to measure the distance between a fire observatory standpoint and a potential fire start point. Based on the vechicals that Firefifithing Department uses for wild forest fires we calculate an average speed of a fire truck on steep slope terrain. The results of our research have led us to targeted conclusions highlighting both gaps in forest monitoring during the high-risk period for large-scale forest fires and forest protection infrastructures.*

Keywords: *Forest fire, prevention, suppression, optimum routes, vehicle speed, peri-urban.*

1. INTRODUCTION & OBJECTIVE

The importance of forests for the planet is indisputable. The existence of life is due to them as carbon dioxide binding CO_2 feeds the atmosphere with O_2 oxygen (Dimitrakopoulos, 2002). One more of their multiple functions is to protect urban areas from floodplains, acting as natural barriers to water retention and aside produce pure water (Stergiadou et all, 2009). One such example is the peri-urban forest of Thessaloniki. It is an artificial forest and was created in the decade after its liberation in 1912, with the first planting of pines in an area of 10 acres in the Evangelistria area. The area today is 30.018 acres. It consists mainly of Aleppo and Thracian Pine. For these reasons, we ought to protect forests against the various hazards that cause their destruction. One of the major dangers of destruction is forest fires (Sivrikaya et all, 2014, Stergiadou, 2014). They have the potential to destroy totally large areas of forest vegetation in a very short space of time (Drosos et all, 2014). The purpose of this paper is to contribute to the effective treatment of forest fires in the peri-urban forest.

2. EXPERIMENTAL METHOD

The method of chose the optimal road net (Stückelberger et all 2007) combined with the information of Fire Department about the type of 4X4 vechicles which are used for forest fires and in conjunction with the 1.5 km radius centered forest fire observatory; is the base of our proposal of an early warning fire announcement and immediate forest fire extinguishing. To measure the distance on the google maps distance calculator tool based on entering the address of a starting point. Then draw a route by clicking on the starting point, followed by all the subsequent points you want to measure. You can calculate the length of a path, running route that appears on a google map. The distance calculator will then display a measurement of the length in feet, meters, miles and kilometers (Fig. 1).

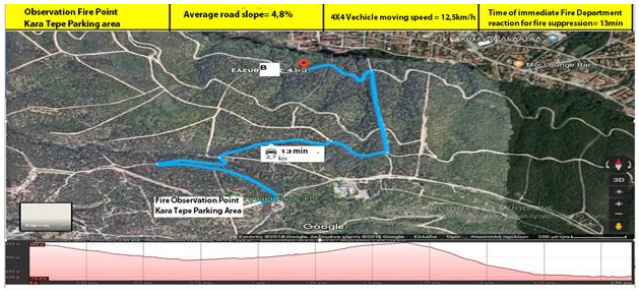

Figure 1. Google map distance and slope calculator between the 1st Fire Station of Thessaloniki and a hypothetical pointed area in peri-urban forest of the city

We calculate the mathematical formulas for average route slope and vehicle speed per hour. Dijkstra's algorithm is the basic methodology used by routing applications like Google's to calculate the above (Albini, 1981, Sharma et. all, 2010) (Figure 2).

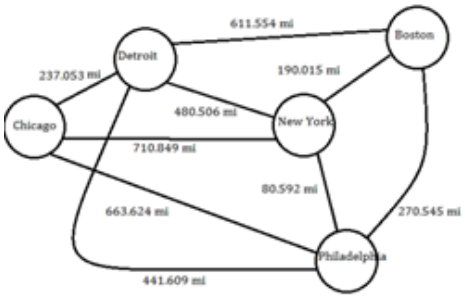

Figure 2. Dijkstra's algorithm-based map representation

Average route slope (%) = $\frac{\text{final altitude - initial altitude}}{\text{total travel distance}}$

Vehicle speed/hour (km/h) = $\frac{\text{route length X 60' (min)}}{\text{the time it takes to travel a route}}$

A scenario method was etablied base on how long away can be a fire fighting vechicle in order to suppress a forest fire within 10' to 15'. Random areas were picked up as fire starting points (recreation areas, pick-nick points, athletic areas-basketball courts, ets) and measured the distances between the three Fire Department Stations or the fire observation station in the peri-urban forest.

3. RESULTS, DISCUSSION & CONCLUSION

Twenty fire start scenarios occurred in the Thessaloniki suburban forest and were examined by one to four immediate possible movements of the 4X4 Fire Brigade vehicles either from the three fire stations or from the four inland forest fire observation sites (Figure 3). After processing the data from the fire brigade, the fire scenarios we set and the fire safety planning of the peri-urban forest we came to the following results:

1) The Eastern area of peri-urban forest is not properly protected from the Fire Departments (blue cycle areas)
2) At the eastern area there are some of properties in the forest
3) The Civil Protection Bureau designates volunteer firefighters as responsible for the surveillance and fire safety of the eastern suburban forest sector.
4) neither volunteers nor their vehicles are deployed on a 24-hour basis in forest fire alert areas

Figure 3. *Google map of research area and a 1.5 km radius centered forest fire observation sites for immediate extinguishment within 10 'to 15'. The yellow cycles are the ones where Fire Department is pointed four 4X4 firefighting vehicles. The blue radius are the ones that are proposed after our research.*

Noting the deficiencies in the issue of immediate and timely notification of forest fire and the movement of fire trucks to the point of first ignition we propose the following:

1) Study on New Road Network Improvement and Improvement in Periodic Forest Areas
2) A name per each forest road must be given in order to be more clear for the Firefighters where to drive ahead

3) New plan of forest fire observation places must be given in order the hole area of the periurban forest to be observed
4) Research into the creation of new water reservoirs to fully meet the needs of the suburban forest water
5) Control of the Thessaloniki Fire Department for complete protection of the city
6) Civil Protection with Fire Fighting Department and Forest Protection Department Office must use a common web application on all workers cellphones that can show them the develpment of a forest fire and the optimal pathway to drive nearby in order to fight it.

A well developed Master Observation Plan for protection and prevention of a forest fire in periurban forest of Thessaloniki will be a step forward to have an everlasting development of the forest and a new era of environmental sustainability.

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