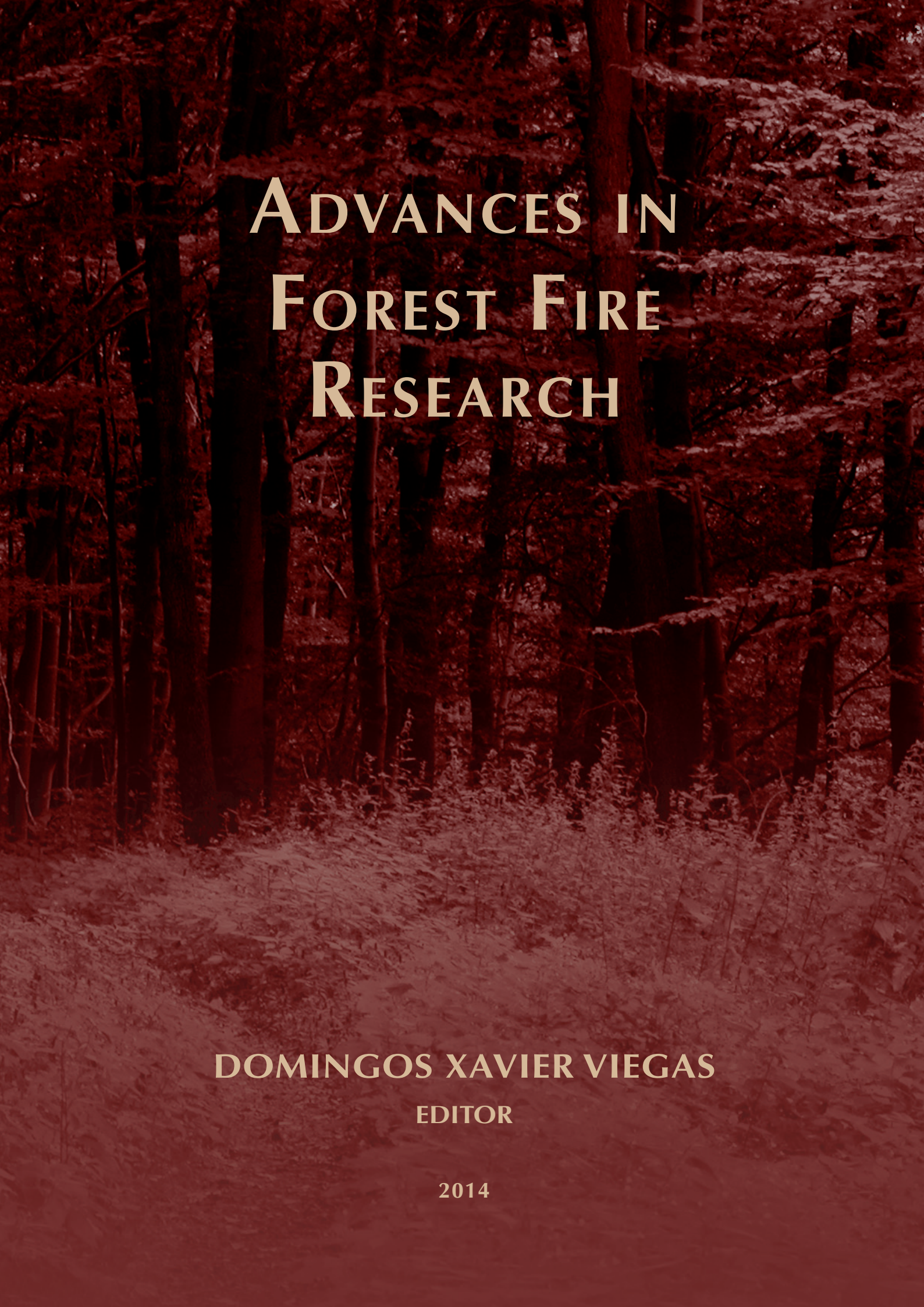

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The development of forest fire danger mapping method for wildland urban interface in Korea

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Abstract
Facilities in wildland-urban interface were main causes of forest fire ignition or protection objects from forest fire. In Korea, many facilities-for example, ancient temples and pensions-lied in wildland-urban interface and suffered from forest fire extremely. For preventing forest fire damage to these facilities, Korea national government designated the wildland-urban interface, which was located within 30m from forest.
In this study, we established some manuals which were resulted from analysis of damaged facilities records in Korea and referred other management tool-FIREWISE and FIRESMART for estimation of the forest fire danger rating around these facilities and a protection of the life and the property. The manual was consisted by two parts. One was related by environment factors (forest species, forest density, slope, a distance from forest and etc.) and another by artificial factors (a condition of road, distance from forest fire attack agency, distance from water source and etc). Theme maps were made by this factor which was graded by this manual and analyzed using ARCGis 9.3. The map was made on three districts (Kyeongjoo-Si, Uljin-Gun and Bongwha-Gun) in Keongsangbuk-Do and the resolution was 10m. In mapping and analyzing, we graded these factors and classified according to this grade rule using G.I.S tool.
In results, the forest fire danger rate in Uljin-Gun and Bonghwa-Gun was much higher than Kyungjoo-Si. Because of Coniferous forest, the forest fire danger rate in Uljin-Gun and Bonghwa-Gun was much higher than Kyungjoo-Si. And forest fire danger rates related with artificial condition in Uljin-Gun and Bonghwa-Gun much higher than that in Kyungjoo-Si.

Keywords*: Wildland-urban interface, forest fire danger map, GIS , Forest fire danger zone*

1. Introduction

In Korea, many facilities-for example, ancient temples and pensions, houses, hospitals, gas stations, powerline, etc. - lied in wildland-urban interface and were exposed by high danger rate from forest fire extremely. The large forest fire in Korea, for example, East region forest fire in 2000, YangYang Forest fire in 2005 and other large forest fire, destroyed many houses and building in wildland-urban interface. Especially, Naksan temple, ancient bell and other Buddhism structure, important cultural properties, were destroyed by Yangyang forest fire in 2005. And many houses in highly urbanized area with urban forest on Pohang-Si were damaged and destroyed in 2012. So , in Korea, central and local government were interested in how to protect structures in wildland-urban interface and to lessen damages from forest fire. Therefore, for preventing possibilities of forest fire damage for these facilities, first of all, Korea national government classified the facilities in forest and wildland-urban interface and designated the wildland-urban interface zone, which was located within 30m from forest.
In U.S.A., Willam E. Mell *et al* (2010) reviewed whole method for reducing structure losses. They focused on fuel treatment, risk assessment strategies and test for fire-resistant designs and metarials. In our country, as packaged measure for forest fire would be needed, we would plan to analyze characters of damaged structures and facilities according to forest factors and others for first steps and would make forest fire danger map for risk assessment in wildland-urban interface for next step.
In many countries, many mapping method for forest fire danger map in wildland-urban interface were developed. In Spain, Roul R. Calcerrada *et al* (2008) focused on socio-economic factors and analyzed

the ignition risk characteristics in Mediterranean regions. In U.S., Robert E. Keans *et al* (2008) made fire hazard and fire risk using FIREHARM. FIRE HARM calculate risks of forest fire from fuel moisture and other fire variables. James K. Lein and Nicole I. Stump (2009) assessed wildfire potentials in wildland-urban interface using GIS based models. The vegetation, a intensity of solar radiation, topographic wetness, population densities and near roadway were using for models from forest fire records

In this study, we analyzed damaged facilities records in wildland-urabn interface in Korea and referred to other management tool for facilities in wildland-urban interface-FIREWISE and FIRESMART. Using these results, we established a manual for estimation of the forest fire danger rating of facilities in wildland-urban interface. This manual must be needed for a protection of the life and the property

2. **Methods**

The manual was consisted by two parts. One was related by environment factors (forest species, forest density, slope, a distance from forest and etc.) and another by artificial factors (a condition of road, distance from forest fire attack agency, distance from water source and etc).

2.1. **The survey of environment and natural and artificial factors**

Field surveys from forest fire records about damaged structure were carried out in Korea from 2010 to 2012. The main damaged structures were house and storage. Especially in Korea, many farmers houses were located in mountainous topology and near to forest. So, we focused on which natural and artificial factor make to ignite structure. For proving these questions, we analyzed the relationship with facility damages and road condition, vegetation, topographical condition, factors for forest fire attack and other relation factors. These factors which were surveyed factors for estimating forest danger rating were referred to FIREWISE in U.S. and other country mapping results. After surveying, we analyzed the relationship and selecting the factor having high relationships.

2.2. **The selection of environment and artificial factor**

After analyzing whole data about damaged facilities and their natural and artificial environment, we selected a few factor for damaging facilities from forest fire. These were main facfor - the number, width, degree and condition of road to access, road sign, space for attack engine, main species of forests, tree height of trees, D.B.H. of forests, tree density of forests, a fuel condition of shrub, a condition of ladder fuel, a fuel condition of surface, a condition of crown, a distance from forest, a gradient of neighboring ground, a existence of water in near and the distance from forest fire attack facilities.

After selecting factors, we found a relationship with damage rating of facilities per factor. And we designated a weight between factors which was referred to NIST reports about estimating house danger rating from forest in wildland-urban interface.

Using these factors, we made theme maps from D.E.M. and digital forest floor map from K.F.R.I.. We used ARCGis 9.3 for making theme maps. And we wrapped these theme maps using ARCGis 9.3 for making a forest fire danger rating map for facilities in wildland-urban interface.

3. **Results**

In results, the forest fire danger rate in Uljin-Gun and Bonghwa-Gun was much higher than Kyungjoo-Si. Because of Coniferous forest, the forest fire danger rate in Uljin-Gun and Bonghwa-Gun was much higher than Kyungjoo-Si. The forest fire danger rate according to the distance from forest in Uljin-Gun and Bonghwa-Gun was much higher than Kyungjoo-Si. Absolutely safety area (distance was above 300m from forest) was 78.6% in Kyungjoo-Si, 52.5% in Uljin-Gun and 48.6% in Bonghwa-Gun. The danger area according to slope was 15.5% in Kyungjoo-Si, 42.1% in Uljin-Gun and 53.7%

in Bonghwa-Gun. And forest fire danger rates related with artificial condition in Uljin-Gun and Bonghwa-Gun much higher than that in Kyungjoo-Si.

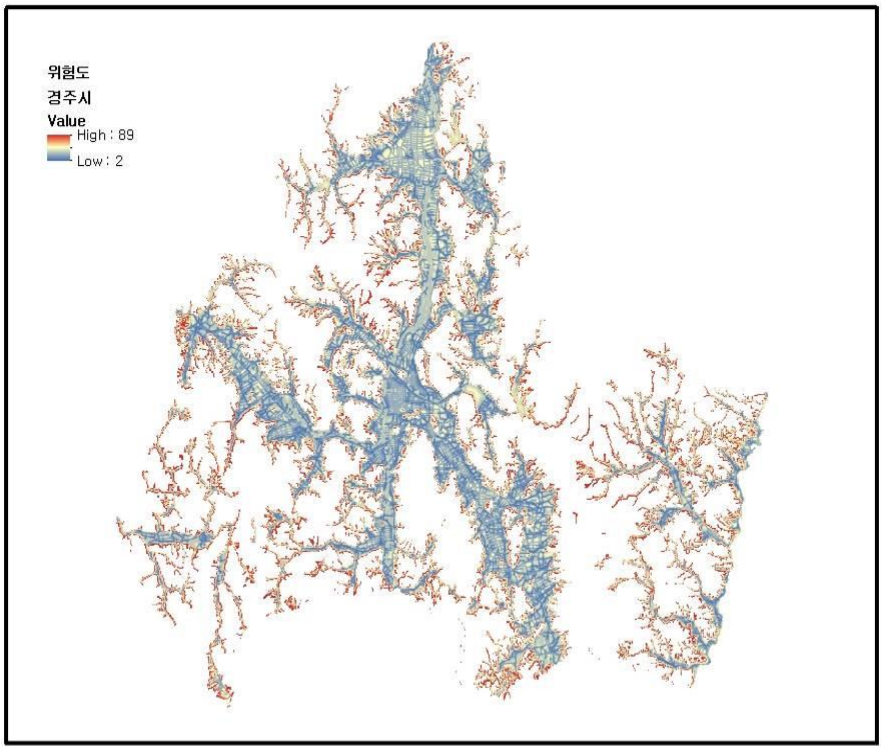

Figure 1. The results of danger rating for forest fire in Wildland-urban interface in Kyeongjoo-SI

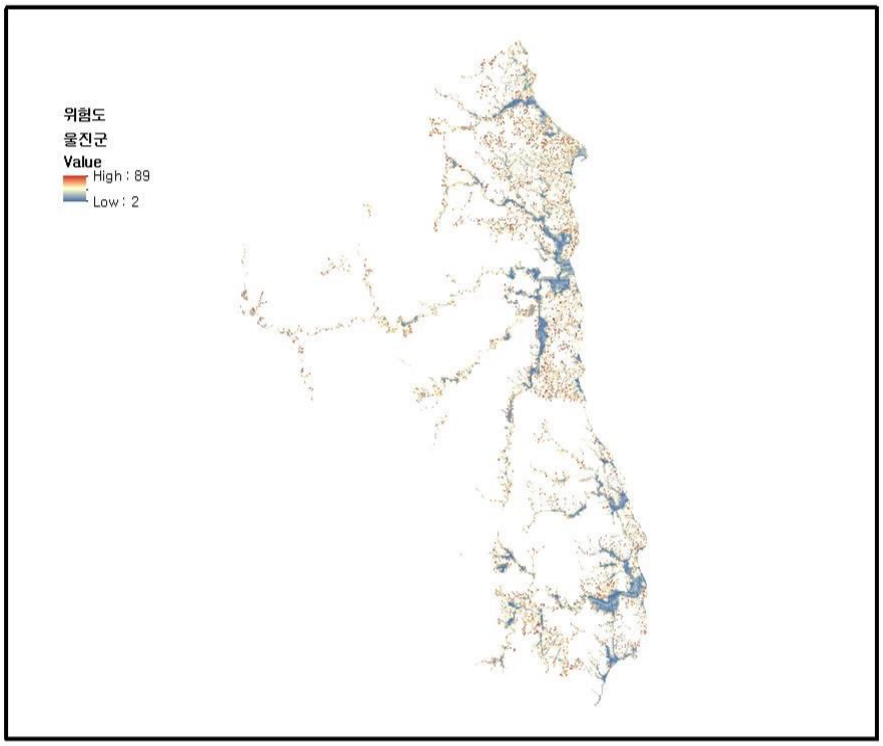

Figure 2. The results of danger rating for forest fire in Wildland-urban interface in Uljin-Kun

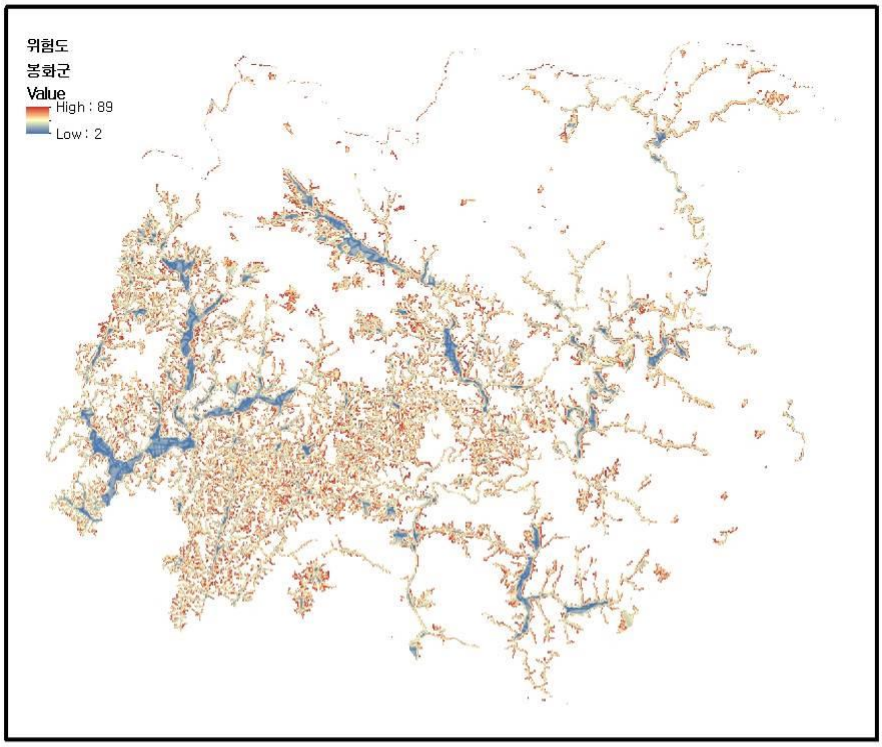

Figure 3. The results of danger rating for forest fire in Wildland-urban interface in Bonghwa-Kun

In results, the proportion of forest danger had a difference between three regions in 5% significant level. For verifying this algorithm, we applied this algorithm to facilities in other region. We tested 11 damaged facilities in wildland-urban interface on Seomi-Ri and Jungmyeong-Ri in Kyeongsangbuk-Do. These facilities damaged from forest fire which occurred in 2011. The mean in a radius of 30m of damaged facilities was 46.98 in 89 scales. the maximum was 70.61. That is over 'danger rate(37/89)' which was referred to home ignition manuals of 'FIREWise'

Using these algorithms, we calculated and estimated the danger rating of main facilities in three regions. In results, Bongwha-Kun was most danger region. An average Danger rating was 44/89. The danger rating according to facilities categories was analyzed. In results, cultural assets were most danger facility category(39.3/89).

The forest management like a fuel management or deploying of forest fire attack resources would be needed for this region and cultural assetsext…

4. **Acknowledgement.**

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