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MODELS THAT RELATE BIOPHYSICS CHARACTERISTICS TO THE PRESENCE OF FOREST FUELS IN CENTRAL MOUNTAINS OF MEXICO

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The forest fires studies must take into consideration three fundamental characteristics of the terrain: the distribution of fuels, the terrain's topography and the weather. That is why an adequate fuel characterization and spatial distribution determination are both critical factors in simulating a fire's behavior. Nonetheless, the determination of the spatial distribution of forest fuel has been one of the greatest challenges that scientists studying forest fires have faced. According to Brown and Bevins (1986), spatial distribution of forest fuel follows a preferably discontinuous pattern.

A terrain's topography will make the accumulation of fuels easier or harder, which leads us to consider the existence of a relation between topographical characteristics and fuel distribution. It is also logical think that t*he amount of dead fuels generated by the vegetation is related to the trees gender and composition in the site*.

This work present an application of l*inear regression methods to determine which* biological and physical characteristics of high mountain zones in central Mexico *have more influence on the fuels distribution and accumulations, and with this selection built a mathematical model* that describe their behavior.

Regression methods use data collected for two different types of variables. Independent variables are those that remain as entry variables for the model, and were derived from the biophysical characteristics of the terrain, such as altitude, slope, aspect, slope shape of the longitudinal and transversal profiles, *microtopography*, fuel distribution, presence or absence of stream, adult trees index, and vegetation composition. Dependent variables are those to which the model adjusts, in other words, the variables obtained as a result of the model. In this application the dependent variables were litter weight, litter depth, and amount of wooden material divided into diametric classes.

For the recollection and measurement of the fuel amount, the linear intersection technique was used, following the guidelines established by Brown (1974) and McRae et al. (1979). A net of ten circles of 0.1 h. was traced within each site to cover a total area of 1 hectare; from the center of each circle three transecting lines of 25 m were traced. To measure the litter weight, an area of 400 cm^2 was traced at the end of each transecting line, and all the vegetal material present in that area was collected. Depth was measured using a ruler every 5 m. along all three transecting lines. Wooden material that was on the lines traced was considered, and grouped in four categories, depending on its diameter (0 to 0.5 cm, 0.6 to 2.5 cm, 2.6 to 7.5 cm, and over 7.5 cm).

A total of 149 circles were sampled, and because the physical and biological characteristics were measured per circle, this was the number of observations. The fuel measurements, taken following the methodology explained above, allowed three measurements per circle for litter weight, because a sample was taken at each transecting line. Because litter depth was taken every 5 m., there are 15 measurements per circle. The information about physical parameters was also taken, including: altitude, slope, aspect, slope shapes of the longitudinal and transversal profiles, micro-topography of the circle, and fuel distribution within the circle. For the biological characteristics, data was collected pertaining to the gender and diameter at chest height for every tree over 10 cm in diameter within the circle. Trees with diameters less than 10 cm were considered, and the same data collected, only within a smaller circle, with radiuses of 8.9, within each circle.

In addition to this, observations were taken when circles had streams, depressions, paths, fire prevention ditches, or signs of deforestation.

The exploratory analysis using all the variables considered in the investigation, done before the model adjustment, give us a general idea of the data collected. As a result of this analysis we said that 82% of the circles did not have depressions, and 93% of them had no ditches, the variables of altitude and slope, were uniformly distributed in their different categories. The vegetation in 55% of the circles was composed of pine or pine-aspen, while 40% of the circles had 70 to 100% adult tree population. Also no circle had a northern orientation, but, besides this, slope orientation had a more or less even distribution among the other categories.

Most circles had irregular or regular micro-topography, and the fuel distribution was regular in 82% of the cases. 85% of the circles had a flat longitudinal profile, while 69% had a flat transversal profile.

Sampling sites were chosen in places that showed little human influence, which is reflected in the statistics for the perturbation variable, which shows that 88% of the circles are unperturbed or moderately perturbed.

The procedure to find the models that best adjusted to each of the six forest fuels is called stepwise, and it consist that from a primary model ($y=x'\beta+\varepsilon$) variables are added or subtracted iteratively until the best adjustment is found. For the variables related with the litter weight and depth, seeing that their distribution was continuous, it was assumed in the proposed models that error would have a normal, or possibly gamma, distribution. The wooden material variables, because they are discreet (counts), led us to assume a Poisson error distribution.

The model that resulted for the litter weight variable shows that the dominance index of adult trees, in the 25% to 50% category, concave transversal profile of the slope, plain longitudinal profile slope orientation and vegetation composition are the biophysical characteristics more related with this fuel presence.

Based on the model, the estimation of the litter depth variable depends on type of vegetation, the altitude between 3100-3220 meters above sea level, dominance index of adult trees in the 25% to 50% category, aspect and transversal profile slope shape as well as the perturbation.

From the model obtained for the wooden material quantity, 0 to 0.6 diameter, variable, we can see that this variable is related to the altitude in combination with the slope incline, the presence of depressions related to the vegetation composition and aspect.

We can use the resulting model for the average value of wooden material quantity, 0.6 to 2.5 cm in diameter, to state that this variable depends on a dominance index for adult trees between 0 and 25%, vegetation composition and perturbation.

Fuels diameters greater that 2.5 cm, are large enough to be used for the population in the study area. Most of the sampling sites are areas where human perturbation is present, so, even though we sought areas with the least amount of perturbation, the results of this investigation show that the quantity of wooden material in the diametric classes of 2.5 to 7.5 cm. and over 7.5 cm., is small; the consequence of this is that the models proposed have poor adjustment.

The models proposed provide an acceptable adjustment and satisfy all the assumptions of generalized linear model theory, thus, it is possible to use these models in order to make predictions for other areas that have similar conditions to those of the sampled sites.

Despite the great variation in the combustible observations, it was possible to determine a set of biophysical variables through which the behavior of combustible materials is explained. By developing four models in which the variables of altitude, vegetation composition, dominance index for adult trees, transversal profile of the slope and micro-topography turn out to be the most influential for the behavior of dead fuels variables.

These models give a selection of the biophysical variables with stronger relationship with the fuels materials characteristics, so that these variables could be considered in general system used to determine the geographic areas with high risk to present fires.