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Analyzing the spread of *Gonipterus scutellatus* forest pest in Spain using space-time Universal Kriging

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INTRODUCTION

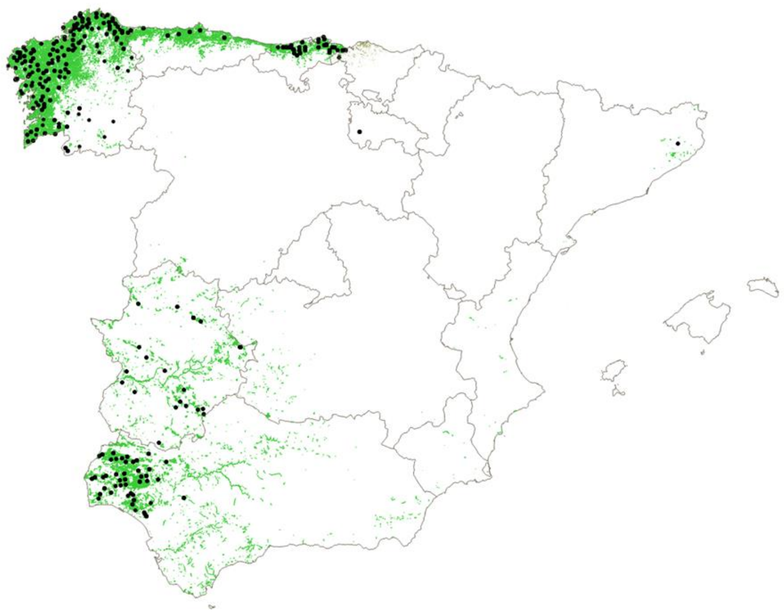
Defoliation induced by the invasive eucalyptus weevil (*Gonipterus scutellatus* Gyllenhaal) is causing significant economic damage to Spanish eucalyptus (*Eucalyptus* spp.) plantations since the 90s. At 2018, Eucalyptus spp. plantations in Spain cover a total area of almost **620000 ha** and produce more than **7.8 mill m³ of merchantable wood** annually.

The damage includes defoliation of the crown, epicormic and stunted growth, and stag-horned or witches broom appearance with clusters of dead shoots. Projections of wood loss indicate that **25% and 50% crown defoliation** can result in **over 20% and 85% loss in wood production**, respectively, over a 10-year growth period.

The aim of this study was to **investigate which drivers influence the spatial distribution of the eucalyptus weevil (*Gonipterus scutellatus*) on *Eucalyptus* spp. plantations in Spain**. We hypothesized that the probability of occurrence of the weevil would vary with the stand and site characteristics, such as temperature and precipitation.

Larval feeding damage on leaves

Adult feeding damage on leaves



MATERIALS AND METHODS

The data set combines the Spanish plots with *Eucalyptus* spp. presence belonging to the network of the European transnational survey (**ICP Forest Level I**) of forest condition in Europe (16 x 16 km grid) and plots measured by regional administrations using similar field protocols aiming to intensify the sampling density.

A total of **264 Eucalyptus plots** were included in the study, where 161 plots showed presence of eucalyptus weevil at some point in the observed period (1986-2019).

The spatio-temporal patterns of the pest outbreaks can be predicted using geostatistical techniques that allows us to account for the spatial autocorrelation of the variables in the analysis, improving the prediction accuracy in terms of bias and error. We applied **spatio-temporal Universal Kriging** to examine the dynamics of *G. scutellatus* and to identify de main site and stand factors associated with the spread of the pest:

$$Z(s,t) = \sum_{k=0}^{p} \beta_k f_k(s,t) + \delta(s,t)$$

Because of high variance in the data set, we applied a **Poisson model** with three thresholds: **>0%, >5% and >15%** of *G. scutellatus* crown damage in the plot.

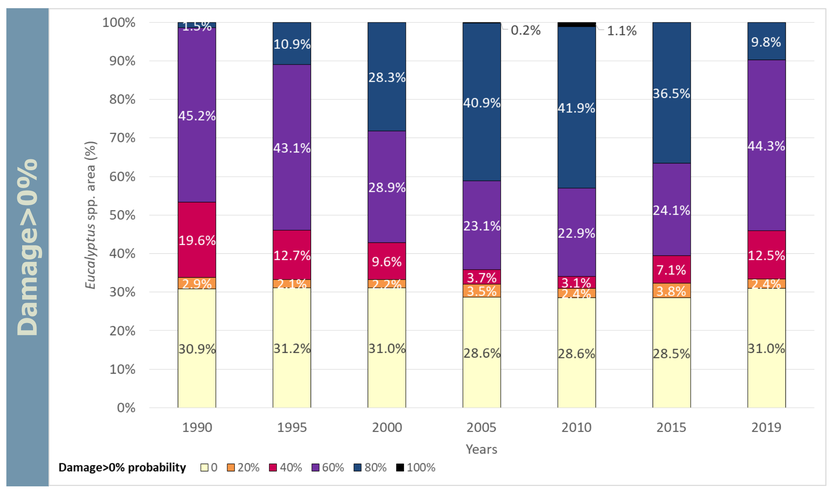
After a model was selected, *G. scutellatus* annual incidence was calculated using Universal kriging in stands with presence of *Eucaliptus* spp. in the **Forest Map of Spain (MFE)**. The MFE provides detailed and homogeneous vector information of the structural type or main use of each polygon (minimum size of 1km²), degree of coverage and main tree species mapped, among others, and is updated regularly (at least every 10 years).

RESULTS

Our results show that damages caused by the eucalyptus weevil have increased in the period 1986-2019, showing that stands belonging to **Atlantic region are more affected than Mediterranean region by this pest** (81% of the Atlantic plots are sometime affected versus just 7% of the Mediterranean plots).

Results show that **pure eucalyptus stands** were more affected that mixed stands, as well as **former summer temperature** (negative relation) and **spring precipitation of the current year** (positive relation) are significant in the incidence of *G. scutellatus*. Altitude and latitude were needed to get the climatic variables.

Finally, **risk maps** of incidence degree were generated to support decision making for pest prevention and control. This study sets up a methodology enabling to understand and simulate pests spread which is essential for risk prevention.



Risk maps example: Damage>0%