Geophysical Research Abstracts
Vol. 19, EGU2017-17578, 2017
EGU General Assembly 2017

Effects of declining oak vitality on ecosystem functions: Lessons from a Spanish oak woodland

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Mediterranean oak woodlands have a great ecological and socio-economic importance. Today, these fragile ecosystems are facing unprecedented degradation threats from Novel Oak Diseases (NODs). Among NOD drivers, maladapted land management practices and climate change are most important. Although it is generally believed that NOD-related declines in tree vitality will have detrimental effects on ecosystem functions, little is known on the magnitude of change, and whether different functions are affected in a similar way.

Here we analyzed effects of tree vitality on various ecosystem functions, comparing subcanopy and intercanopy habitats across two oak species (Quercus ilex and Q. suber) in a Spanish oak woodland. We asked how functions – including aboveground net primary productivity (ANPP), taxonomic diversity, and litter decomposition rates – were affected by oak trees' size and vitality. We also combined measurements in the ecosystem function habitat index (MEFHI), a proxy of ecosystem multifunctionality.

Field research was carried out in 2016 on a dehesa in southern Spain. We used a stratified random sampling to contrast trees of different species affiliation, size and vitality. Tree vitality was estimated as crown density (assessed via hemispherical photography), and as tree vigor, which combines the grade of canopy defoliation with proxies for tree size (dbh, height, crown height and crown radius). For each tree (n = 34), two plots (50 x 50 cm) were located; one in the subcanopy habitat, and the other in the intercanopy area beyond the tree crown's influence. On all 68 plots, moveable cages were placed during the main growth period (March to May) to estimate ANPP under grazed conditions. Litter decomposition rates were assessed via the tea bag index. ANPP and the biomass of grasses, forbs and legumes were recorded via destructive sampling. To take plots' highly variable environmental conditions into account, we recorded a suite of abiotic and biotic characteristics such as the received radiation of the hydrological year, slope, aspect, soil depth, grazing offtake, as well as the cover of bare ground and litter. The geo-morphological data comes from a high resolution UAV generated digital elevation model. We used GLMMs and LMMs to assess effects of tree health on ecosystem functions, statistically controlling for plots' variable environmental conditions.

We found ANPP to be higher in intercanopy habitats and beneath trees with a low vigor or crown density. In contrast, highly vigorous trees increased legume biomass and grass biomass. Responses of other ecosystem functions were mostly not significant, although a lower diversity was found under trees with intermediate vigor. In the case of MEFHI, we assume that positive and negative responses have partly masked each other.

Our results underline that a NOD-related decline in tree vitality has complex effects on ecosystem functions. For example, it increases forage quantity but decreases forage quality. Ecosystem functions under trees with a low vigor were in most cases similar to those in adjacent open habitats, showing that the presence of vigorous (i.e. old and vital) trees is critical for maintaining ecosystem functions on a landscape level.

Keywords: NODs, dehesa, ANNP, decomposition, herb diversity, habitat degradation