Monitoring for Pests and Diseases in Native Oak Woodlands: The Case of Acute Oak Decline in the United Kingdom[1]

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Abstract

In recent years, a novel form of decline has been observed in southern and central England. This syndrome has been termed acute oak decline (AOD) and affects native oak, *Quercus petraea* and *Q. robur.* Typical symptoms include bark cracks that weep dark exudates, which are caused by necrotic patches in the inner bark. Studies show bacteria are consistently isolated from lesion edges, with two species, *Gibbsiella quercinecan*s and *Brenneria goodwinii*, thought to cause tissue necrosis. *Agrilus biguttatus* (a native beetle, with apparently increasing populations) is often reported at affected sites. In fact, the small samples of inner bark taken for bacterial isolations revealed larval galleries in 36 of 38 AOD affected trees. Here, we present the findings of two monitoring exercises that were conducted to document AOD dynamics at different spatial scales. At the local scale, within stand dynamics were monitored at eight locations across England. This work was complimented by a national scale survey, which was used to investigate environmental predisposition factors.

The local scale: A 7-year study on the spatial and temporal dynamics of AOD, and occurrence of *A. biguttatus* was conducted at eight geographically separated sites, giving a first description of its epidemiology. Findings suggest affected trees occur in localized clusters rather than at random throughout the plots, pointing to a local, biotic, cause rather than wider scale environmental effect such as drought. In addition, contagion, spread between neighboring trees, was demonstrated at one heavily infected site. Lightly infected individuals have been shown to form callus over the previous year's stem symptoms and enter remission. This finding highlights the need for host predisposition, where drought may have a role, and suggests scope for resistance and management options.

AOD symptoms co-occur on the same trees as D-shaped exit holes, although many fewer oak show these external signs of the beetle. This is perhaps surprising given that galleries are consistently found below the bark, but a likely product of both a cryptic larval phase and successful host defenses. Beetle emergence is predominantly linked to a few heavily declined trees, with further stem bleeds occurring on trees in close proximity to these locations.

The national scale: Regulatory surveys to detect and establish the distribution of pests are resource intensive and costly. Advances in technology, including smartphones apps for symptom recognition and reporting, have enabled the collection of species distribution data by volunteers to occur with increasing

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[1] A version of this paper was presented at the Sixth Sudden Oak Death Science Symposium, June 20-23, 2016, San Francisco, California.

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frequency and accuracy. However, what data from volunteer sources tell us and how they can be best used to inform and direct official survey effort is not clear.

Here an extensive dataset on AOD gives a unique opportunity to ask how verified data received from the public can be utilized. Information on the distribution of AOD was available as (i) systematic surveys conducted by Forest Research throughout England and Wales (ii) AOD sightings reported through land owners, land managers, and members of the public (termed "self-reported" cases). Results indicate that the self-reporting data was representative of the infected area. By using the self-reported cases at the design stage the systematic survey could focus on defining the boundaries of the affected area. This maximized the use of available resources and highlights the importance of developing novel strategies tailored to volunteer programs. This example represents one of the first quantitative evaluations of the use of citizen science to estimate the distribution of a plant disease.

The survey data have been used to inform epidemiological models and to examine the relationship of AOD with climate and biogeographical variables, especially those that influence water availability.