

THERMOGRAPHY: a non invasive method to detect hidden damage in trees

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Thermography is a well-known non invasive investigation method that is widely used world-wide in dozens of scientific, technical and health applications (1, 2, 3, 4, 5). This method detects the presence of gaps and/or unhomogeneous areas in the bodies investigated, measuring their surface temperature. In correspondence with the damaged areas a surface temperature different from that of the healthy ones is measured because of different thermal properties in the two areas. The system used, a portable IR Camera, provides black-and-white or pseudo-colour images of the filmed area in real time.

The use of this method to detect tree decay was introduced by Dr. G. Catena and his co-worker L. Palla in 1985. In the case of trees, the surface temperature in correspondence with the damaged areas is lower than that in the healthy ones.

The investigation is very easy: the camera is pointed to the specimen to be analysed and in 1/30 sec the thermal image appears on the screen. If the surface temperature distribution of the area investigated is homogeneous, no internal decay is present, and the investigation can proceed to another tree. In black-and-white images any internal damage is rendered in a shade of grey different from that of the neighbouring areas, and in a colour different from that of the neighbouring areas in pseudo-colour images. If the image shows discontinuity in colour, but no superficial damage that can modify the thermal image is seen on the plant (decortication, moss, pruning scars etc.), then internal decay is present. That is why, this technique finds its best use within the VTA (Visual Tree Assessment), to integrate the visual tree assessment.

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Thermography allows the presence of possible tree decay to be detected, localised and quantified in 1/30 sec., that is the time necessary for the camera to provide images of wide portions of the tree examined (Fig. 1), unlike what happens with most of the instruments currently used that only give information at the height or on the point assessed. Generally, 4-5 images are enough to know the situation of the whole tree: it is possible to diagnose the condition of branches up to 20-25m of height, from the ground (Fig. 2-B); for greater distances, a telephoto lens is available.

The fundamental importance of this method especially and mainly in the case of healthy-looking trees can be clearly understood (Fig. 3-A). An expert user can judge if the damage is serious without resorting to invasive instruments that can anyway be employed by an unexpert operator on actually damaged plants and at the very points that provide data on the plant's stability (Fig. 4). Consequently, the screening of urban trees is time-saving, and safety is improved, thus avoiding the dissemination of pathologies with the random use of invasive instruments to localise the extension of decay. Moreover, peculiar surface temperature distributions at the base of the tree, in contact with the ground, point out that damage is certainly present at the root system level (Fig. 3-A). However, the system cannot "penetrate" the ground and give direct information on the condition and distribution of the root system. It is possible to record and process images on a PC and put them in a database so as to use them to reliably monitor the development of damage over time by simply comparing two series of thermal images (Fig. 5).

The technique has been successfully used on thousands of plants of many different species, both broad-leaves and conifers, but also numerous palm trees (Fig. 6 and 7).

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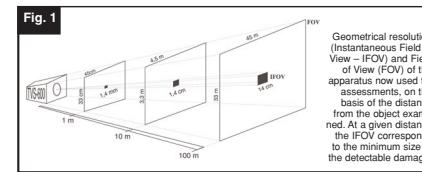
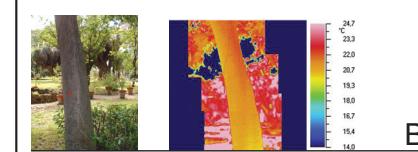
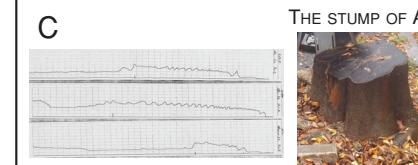


Fig. 1 A HEALTHY SPECIMEN OF *Celtis australis*



A DAMAGED SPECIMEN OF *Celtis australis*



The thermogram (A) of a *Celtis australis*, presenting a a pruning scar on the branch in the foreground, and a similar one at the back of the trunk, revealed the presence of internal damage going from the base to the branches (in light blue/blue-green). The colour distribution revealed the presence of seriously damaged tissue at the root level (in blue). The thermogram (B) shows a healthy cell. The clients wanted to perform an investigation with a dendrodimeter (C): the first profile was taken 8cm below the ground level, the second 94cm above the ground level, while the third profile was performed by keeping the instrument inclined. The stump shows the small tree decay already at 40cm from the ground, confirming the data presented by the thermogram.

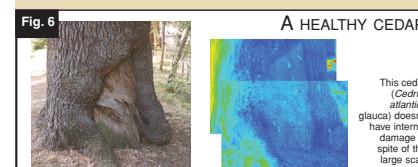


Fig. 6 A HEALTHY CEDAR

This cedar (*Cedrus atlantica glauca*) doesn't have internal damage in spite of the large scar.

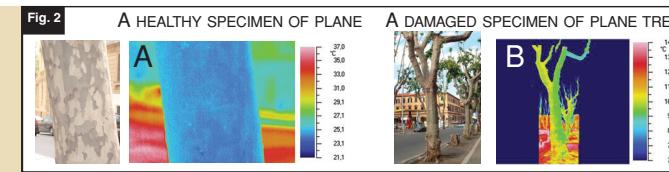


Fig. 2 A HEALTHY SPECIMEN OF PLANE

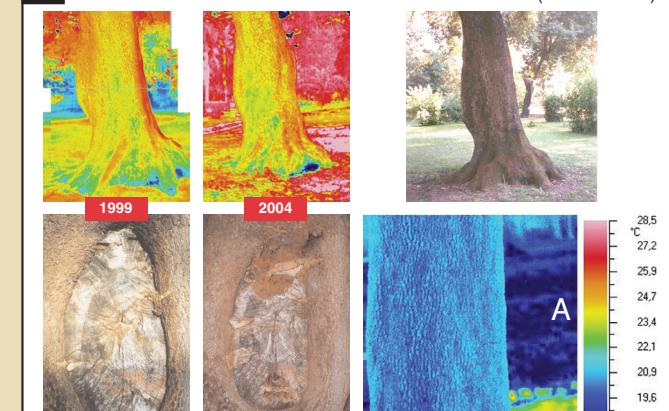
B A DAMAGED SPECIMEN OF PLANE TREE



A DAMAGED SPECIMEN OF *Laurus nobilis*

This bay tree (*Laurus nobilis*) only presents a small cavity full of debris, near an old cut at the fork level. The relevant thermogram shows serious damage in blue and dark green from the base to the bark. The relevant damage is located at the base of the trunk, where the tree is leaning. The tree has a cavity or badly damaged tissue was present: water flew out of the hole. (A) The auger penetrated for 10cm before failing to grip tissue, but no water came out of the hole. (B) The auger penetrated for 10cm before failing to grip tissue after penetrating for 20cm.

Fig. 4 THE FOLLOW-UP OF A DAMAGED *Quercus ilex* (1999 - 2004)



The comparison of thermal images taken in different years allows the development of internal damage (blue, light blue, green and yellow) to be documented. The two photographs of the pruning scar situated, on the back of the trunk, at 1.5m from the ground are contemporary to thermograms: the first one shows an intact surface, the second and most recent one presents two opposite deep cavities full of mushrooms: two big bodies are evident on the wounds. The photo of the holm-oak (*Quercus ilex*) shows no visible damage on the rest of the trunk. The thermogram of a healthy *Quercus* sp. is shown in (A).

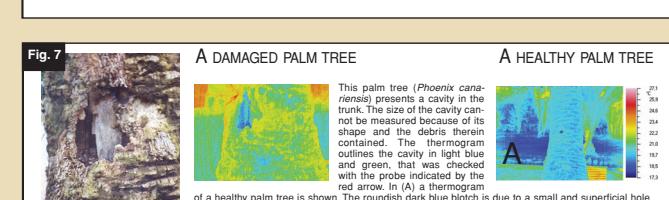


Fig. 5 A DAMAGED LIME TREE

An old apparatus, based on a different scanning element, was able to detect serious damage in this lime tree (*Tilia cordata*) from the root system to the branches. The tree presented a lengthwise crack at the base and pollard-induced damage at the base. The relevant thermogram shows serious damage going from the collar area to the fork (B). Lighter stains are due to the sunlight filtering through the leaves. The tree was dead and was cut down with a chainsaw. As the trunk was cut from the top, decay appeared in the branches, the fork and in the top part of the trunk (C). In (D) hollow logs above the collar are shown, at the crack level. The thickness of the hollow logs is about 10 cm. Finally (E) presents the stump that was easily opened flat, and showed the heavily damaged root area.