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Estratto da: *Atti della Fondazione Giorgio Ronchi*
Anno LVII, n. 3 maggio-giugno 2002

Tip. L'Arcobaleno s.n.c. - Via Bolognese, 54 - Firenze
Firenze 2002

# A thermograph to spot tree hazard

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SUMMARY. – *The presence of damage or cavities in trees in urban centres poses serious problems, in that the trees themselves or parts of them may snap off, thus causing serious damage to people or things. The surveying systems currently used are generally invasive, since they envisage that holes be made into trees. Almost all these systems entail long periods to be carried out and the use of supports in order to survey the aerial parts of the plant; moreover, the information collected through these methods is relative to the point or section of tree where the measure has been carried out, and also monitoring the progress of such phenomenon over time proves difficult to implement. On the contrary, the use of a portable IR camera allows to detect the presence of possible damage and show its extension, since on the camera display, the thermal images of wide portions of the plant itself appear in real time. This method is non-invasive and completely harmless also to man, and is very fast, since it allows to analyse also the aerial parts of the plant from the ground. The system, moreover, allows to check the situation over time, by simply confronting the relative images.*

## 1. Introduction

The detection of internal tree damage: cavities and decaying tissue is a serious problem for municipalities and plant pathologists alike in that it is usually discovered only when there is a sudden collapse, often creating a serious threat for public safety. The danger of the phenomenon is increased by the fact that often only minor signs of the damage are visible on the exterior – a small hole, decortication, the stump of a branch – that only an expert is able to equate with the damage such signs can conceal.

The proposed method is based on the assumption that the presence of a discontinuity in the internal structure of plants which is due to a cavity or decaying tissue, provokes a decrease in thermal conductivity in the affected area compared to the surrounding undamaged part. There is

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therefore an uneven distribution of surface temperature between the two areas, the damaged one, where the alteration is present, is colder.

This technique presents some important advantages if compared with the systems used at present for the same purpose. These can essentially be divided into four categories which include *i)* tapping the trunk with a hammer and interpreting the sound produced, *ii)* the extraction of a core, for example with a Pressler auger, and the immediate examination of the internal tissue, *iii)* the insertion of a probe directly into the trunk, *iv)* non-invasive examination using radioisotopes or radiographic systems. Almost all of these methods are time consuming however, and require a number of operators and the use of ladders or scaffolding to reach the uppermost parts of the tree. The methods that require the carrying out of holes, even very small ones (2-3 mm), can further damage an already ailing plant by causing the breakdown of its defence barriers and encouraging the spread of pathologies or fungi possibly present. Furthermore, the numerous holes that are necessary to detect and above all to measure a possible cavity, even though they are closed with wax or special mastics, might become a spread route for parasites and pathogens. Finally the use of radioisotopes or radiographic systems can be dangerous because of the radiation they emit.

On the contrary, the use of equipment that can detect infrared radiation emitted by the tree under examination due to its temperature and then to visualise the distribution of this temperature on a monitor, allows us to spot possible internal damage without even having to touch the tree; 1 – 2 operators are needed for the measurements and the use of scaffolding is not necessary, in that the shots of even the tallest trees can be carried out from ground level. The distance from the plant does not influence the results of the system, at least up to about 20-25 m: greater distances could make the detection of small-sized damage difficult.

## 2. The system

It is possible to use apparatuses working both in the 2.5-5.6 μm (1, 2) and 8-14 μm (3, 4) wavelength intervals though they have high resolving power (IFOV) and thermal sensitivity. Such systems have to be able to visualise the images of the area filmed on a monitor. The images presented here have been taken using a hand-held AVIO TVS 610 camera, which is sensitive in the 8-14 μm wavelength interval. This system is equipped with a sensor made up by a 320×240 microbolometers matrix, which doesn't need to cool down and provides black and white and colour images of the area under investigation. The sensor, the commands and the 5″ display on which the thermal image appears in real time are gathered in a single apparatus, which is slightly bigger than a common TV camera and is equipped with a battery, which allows up to 4 hours of continuous functioning. The camera only weighs 3 kg all included. With this system, the thermal images can be recorded with a mobile videocassette recorder or stored on to a PCMCIA Compact Flash card so that they can be transferred on to a computer to be processed and transformed in bitmap images through a purpose-built software. A reference scale present only on original images (*.iri) allows to immediately assess the differences in temperature present.

In black and white images, the existence and size of possible damage are shown by the presence and size of an area presenting a darker shade of grey than the surrounding area. In colour images, the damage is revealed by an area showing a colour different from the surrounding one.

The investigation is carried out by pointing the lens to the chosen tree from the ground and assessing the images of the various areas filmed. Damage is present where there is a thermal discontinuity (different shade of grey or different colour) which is not justified by surface damage on the trunk or bark.

The system only spots the presence of damage, i.e., there is not the possibility to distinguish the presence of a cavity from damaged tissue. This is not a limit, since both situations represent threat to tree stability.

## 3. Experimental

In the photograph in Fig. 1, the base of a bay-tree and a stump showing two cavities in the cutting surface, are visible in the foreground; on the left an old stump with partially rotten tissue can also be seen. The trunk doesn't present any sign of damage, if not a small opening (not visible in the photograph) at the base on the side near the stump in the foreground. The probe visible in the photograph has been inserted in the above-mentioned opening, into which the probe penetrated 10 cm. The thermography in Fig. 2 shows that the entire trunk base, rendered in dark grey, is damaged as most of the stump opposite to it. The damage narrows as it goes up the trunk (lighter shades of grey). The damage in the stump in the foreground is not homogenous: the tissue surrounding the cavity in the foreground has the same shade of grey as the least damaged part of the trunk. A quick inspection of the damage present has been made by inserting the metallic probe (Figs. 1 and 2) or a bent metallic probe in the holes present. The size of the cavity in the trunk and the damage in the stump in the foreground has thus been confirmed. The probe has penetrated 50 cm in the cavity near the trunk (Fig. 1), whereas it penetrated only 10-odd cm in the cavity towards the observer.

FIG. 1

Photograph of a bay-tree and a stump showing two cavities in the cutting surface. The probe has been inserted in a hole present at the base of the trunk hidden by the stump which constitutes the only sign of damage present on it.

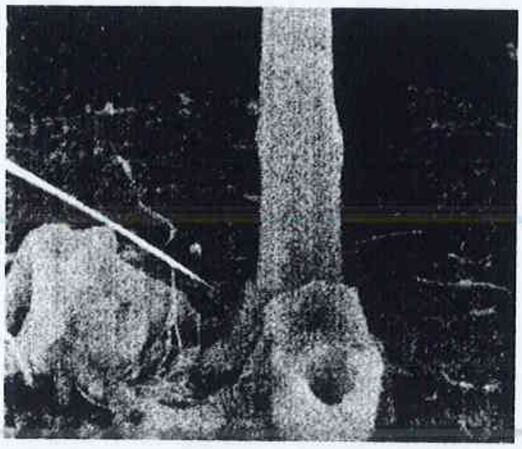

FIG. 2

The thermal image shows that the trunk base and most of the stump opposite are damaged (darker shades of grey) and that the size of the damage narrows as it goes up the trunk. The tissue surrounding the hole in the foreground is less damaged that the rest of the stump, since it has the same lighter shade of grey as the upper part of the trunk.

Thermography can also spot the presence of damage in its early stage. Fig. 3 shows a bay-tree. Its trunk has a longitudinal fold, which has partially encompassed the almost totally rotten stump of another bay-tree. The thermal image in Fig. 4 shows the existence of damage (given in dark grey). Its presence has been checked by inserting the above-mentioned metal probe into the hole at the base of the trunk. The image also shows that such damage is limited to the area of the fold and narrows as it goes up along the trunk (the grey shade is lighter than that at the base). The assessment of this situation has been done by taking a core of tissue in the area shown by the arrow: the damage has proved to be limited to the first centimetre underneath the bark.

FIG. 3

Picture of a bay-tree, which has encompassed an almost totally rotten stump. The only "visible" sign is a longitudinal fold in the trunk's lower part.

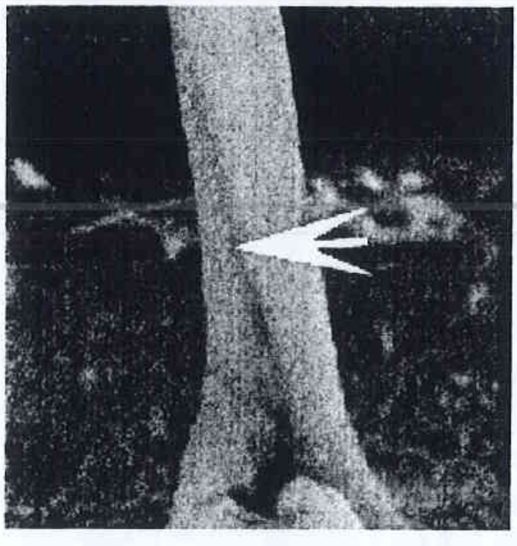

FIG. 4

The thermal image of the bay-tree shows the presence of damage. The damage narrows as it goes up the trunk and is anyway restricted to the fold area (darker shades of grey). In fact a core extracted from the point shown by the arrow has confirmed that the damage only concerns the first centimetre underneath the bark.

## 4. Conclusions

Even though the images shown are few, they point out that thermography is a reliable method to spot the presence of damage within trees. When thermography is applied to hundreds of trees in urban centres, it proves an excellent tool in order to reliably distinguish the undamaged trees from the damaged ones in a short time. Therefore, invasive tools will be used only onto damaged trees in order to assess the damage spotted. The benefits linked to the reliability, fastness and harmlessness of the investigation make up for the relatively high cost of the system and the initial difficulties in interpreting thermal images.

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