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ADVANCED INFRARED TECHNOLOGY AND APPLICATIONS

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A New Utilization of Thermal Infrared Radiation in Studying Vegetation

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The presence of cavities in trees constitutes a danger for the survival of the specimen as they can be a receptacle for parasites, fungi or bacteria; it is therefore important to detect the cavities since their first formation in order to avoid that the development of the above mentioned organisms weakens the tree to its crash with great danger, if it stands by a road, for the passers-by.

To date internal cavities are detected or using the method, introduced by Shigo at the end of the 60'es (Shigo, 1969), consisting in measuring the electric resistance across the tissues or examining the core extracted with a Pressler auger or, finally, tapping the trunk with a hammer and listening to the sound produced. All these methods need ladders or scaffolding (and so a ground crew) and therefore are time-consuming. The first two methods, besides, constitute a danger for the plant in that the holes requested for their realization, even if closed with waxes and artificial barks, can be a breakthrough for pathogenous agents and parasites.

The proposed method uses thermal IR radiation, as already done in the medical and industrial fields, to highlight the presence of an internal tissue discontinuity. Actually, the presence of a discontinuity within the target produces a non homogeneous structure that is made evident by an uneven distribution of the surface temperature. Hence, the presence of a cavity or of rotten tissues is revealed by a non homogeneous temperature distribution between the zone interested by the phenomenon and the safe ones all around.

The main advantage of this method is that it is operated from a distance, without touching the tree at all: besides, as it is no needed any scaffolding there is no need of ground crews. The distance of the apparatus from the target seems not to affect the image rendition, at least from the distances we use to operate (15-20 metres): takes could be made even from larger distances but with the possibility of missing the smaller cavities.

During the years for the research have been employed several thermal scanners, all working in the field 2-5,6 microns: the images presented here have been taken or directly on the screen with a camera, or recorded on a video tape and later photographed on a TV monitor or, finally, recorded on a video tape and later printed by means of a videoprinter.

Till now, some hundreds of trees of several taxa have been examined: "Turkey Oak" - *Quercus cerris*, "Hungarian Oak" - *Quercus frainetto*, "English Oak" - *Quercus robur*, "Cork Oak" - *Quercus suber*, "Holm Oak" - *Quercus ilex*, "Cedar of Lebanon" - *Cedrus libani*, "Deodara" - *Cedrus deodara*, "European Silver Fir" - *Abies alba*, "Umbrella Pine" - *Pinus pinea*, "Maritime Pine" - *Pinus pinaster*, "Mediterranean Hackberry" - *Celtis australis*, "Hackberry" - *Celtis occidentalis*, "Lime" - *Tilia sp.*, "Plane" - *Platanus hybrida*, "Bay Laurel" - *Laurus nobilis*, etc. (see References).

The following figures show the most interesting situations found during the years.

In fig. 1 it is shown the first tree investigated in 1985 at the Botanical Gardens of the University "La Sapienza" of Rome: it is a specimen of *Celtis australis* that has on the trunk a large hole probably due to the loss of a main branch. The thermogram of the zone immediately below the hole, fig. 2, shows the existence of an irregular distribution of the surface temperature due to a non homogeneous structure in the trunk. Even above the hole zones of discontinuity have been highlighted and are displayed by darker tones of grey: fig. 3. As the specimen was healthy it has been avoided to use harmful methods to confirm the findings so the consistency of the internal tissues has been controlled only by inserting stylets in the holes present on the trunk: it could be

Fig. 1

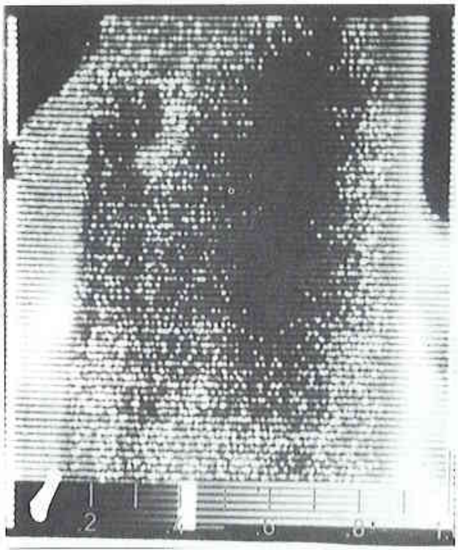

Fig. 2

argued, hence, that the cavities have been originated by the attack of pathogenous agents on the unprotected tissues owing to the loss or the pruning of branches.

Fig. 4 shows, for the sake of comparaison, the thermogram of a safe tree: it is evident the uniform distribution of the tones of grey; the darker stripes represent the cracks of the bark, peculiar to this taxon (*Tilia sp.*).

The following images are related to a Plane (*Platanus hybrida*): in fig. 5 it is possible to see two large holes one at the base and the other at the level of the bifurcation; the corresponding thermogram, made with a different scanner, shows that the two cavities are not communicating (and this fact has been as usual verified by the means of stylets); these cavities are probably of different origin: the one below is due to the traffic as the tree stands very close to a road and that above is due to the loss of a main branch.

The thermogram of fig. 6, related to the side of the tree opposite to that of the photography of fig. 5, shows that the cavity at the bifurcation goes upwards in both branches but it is larger in the right one, as shown by the distribution of grey tones.

One must be very cautious when observing a taxon for the first time: the difference of barks (plain, wrinkled, thick, cracked, thermally insulating as the cork, etc.), for instance, is responsible of a difficult interpretation of what is rendered on the thermogram.

Fig. 7 shows the thermogram of a Cedar of Lebanon (*Cedrus libani*) with two dark patches on the trunk: at a superficial examination or one made by an unexperienced people, they could be interpreted as produced by a discontinuity in the internal tissues:

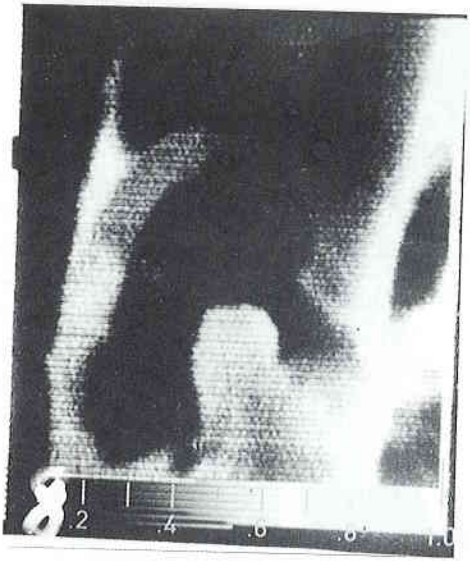

Fig. 3

on the contrary they are the thermal image of two scars in the bark resulting of a branch pruning. The check examination made by knocking the trunk with a hammer and listening to the sound produced, confirmed the wholeness of the trunk.

The system allows to point out the holes produced by parasites and to distinguish them from bark defects. Fig. 8 shows a main branch of an ancient monumental Oak

Fig. 4

Fig. 5

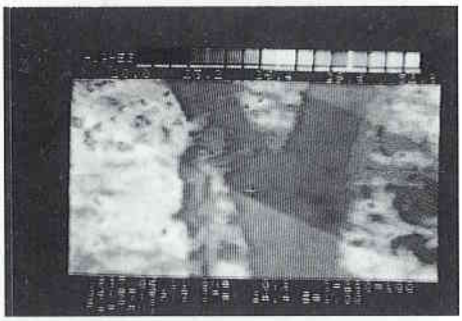

Fig. 6

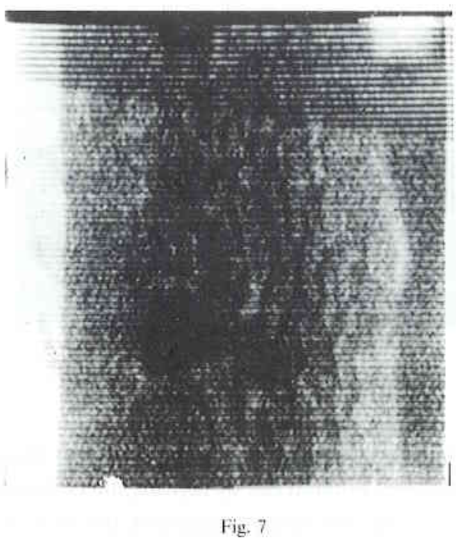

Fig. 7

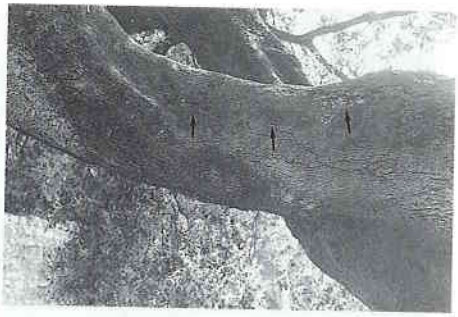

Fig. 8

Fig. 9

Fig. 10

(*Quercus ilex*): the plant presents several holes produced by the attack of a parasite (*Cerambyx cerdo*) in the zones pointed out by arrows; the corresponding thermogram, fig. 9, allows to distinguish the true holes (arrows) by the bark defects due to cracks.

From the researches held up to now and outstanding, it seems to recognize a survey system quick running, reliable, easy to use, that can be an helpful instrument to whom are engaged in the management of the green.

The use of a polaroid-type camera allows to furnish a suitable documentation to the technicians and the experts to decide how to make the remedial intervention or, on the contrary, to cut down the irretrievable specimen, as in the case of the Lime (*Tilia sp.*) of fig. 10: this tree, because of an heavy attack of *Ganoderma* was so unsteady to swing at the simple pressure of a hand. Looking at the photograph it is possible to see the extension and the gravity of the fungus activity on the tissues: the damaged ones are rendered in darker tones than the residual safe ones.

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