Air Pollutants

Smog, the term commonly used to refer to air pollutants in general, technically applies to smoke and fog as presently found in London where it is still a critical problem. Used in this sense, however, the term applies to the atmospheric condition in only a few areas at the present time. The serious air pollution in the Los Angeles area, and being discovered in many other areas, is neither smoke nor fog. One of its chief characteristics is its high ozone concentration and the resulting strong oxidizing ability. It cracks rubber, causes eye irritation and damages plants in a very specific manner. After years of careful study, some of the components of this pollution have been sorted out. This section discusses the more important ones, their effects on vegetation, and lists a number of sensitive and resistant plants.

Regarding sensitivity, it must be pointed out that plants are most sensitive when young. Petunias are more sensitive in the 4 to 7 leaf stage than at any other time. Small seedling pansies are quite sensitive, but plants in the flowering stage are rarely injured. Therefore, any lists of resistant plants are actually relative to the state of growth.

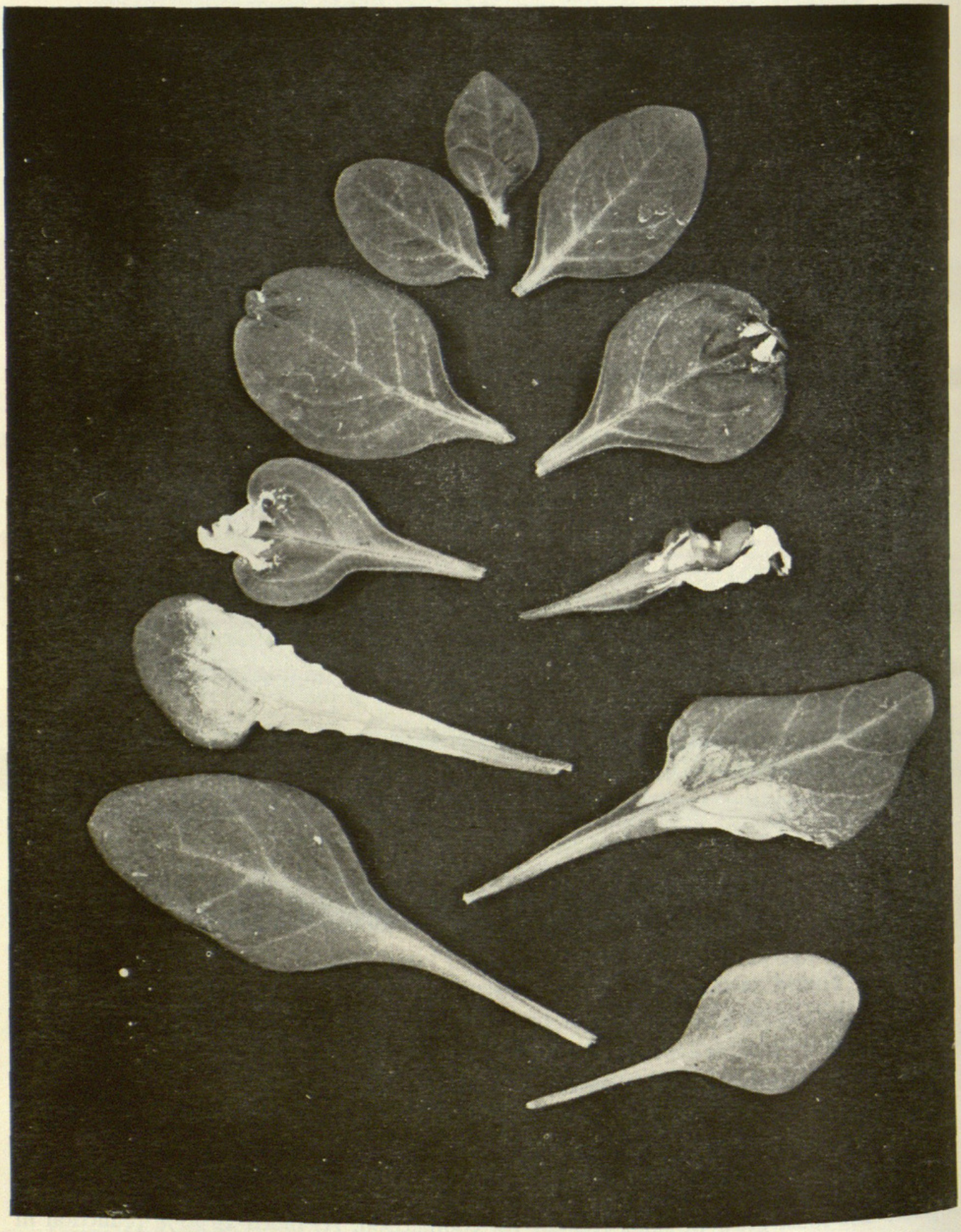
PAN

This term refers in general to a group of compounds belonging to the chemical family of peroxyacylnitrates or more specifically to one member of the group, peroxyacetyl nitrate. (1) This compound and others related to it have been shown to produce the major symptoms observed on days of high pollution when plant damage occurs. (2) These symptoms are as follows:

Silvering: This occurs on the lower surface of the leaves of plants, such as spinach, chard, beets, petunia, and snapdragon. It varies in expression from a silvery appearance on spinach to a bronze on table beet and a milky white on snapdragon. Small plants and young leaves are most sensitive.

Banding: Found on most sensitive plants, banding is probably the most common symptom. Because cells of young leaves at one brief stage of growth are far more sensitive than at any other time, and since most leaves mature progressively, successive bands across the leaves are produced by smog each day it occurs. This symptom is readily observed on grasses, such as annual blue grass, wild and cultivated oats, barley, and occasionally on kikuyu and rye. It is also apparent on mimulus, fuchsia, petunia, and snapdragon.

Growth reduction: This is a very serious, though less obvious symptom, since to observe it plants also must grow in smog-free air for comparison. As much as 90% reduction in growth has been noted over a period of several months on some young plants grown in ordinary air compared to identical plants grown in filtered air for the same length of time.



Pan type damage to petunia. Injury occurs at the tip of the youngest mature leaf and moves toward the base of the oldest damaged leaf with no injury to young immature leaves or to the older mature leaves, a most specific common symptom.

Cellular collapse: This, of course, can be observed only with a microscope. Cells in the interior of the leaf surrounding the stomata collapse and dehydrate without disconnecting from each other and the space which they occupied becomes filled with air. This accounts for the silvering and banding—silvering on leaves with a well-developed palisade layer, which appears to be resistant, and damage completely through leaves with no palisade, such as endive, grasses, or very succulent petunia. (3).

The following is a list of some of the more sensitive and resistant plants to the PAN type of damage:

CROPS

SENSITIVE		RESISTANT	
spinach	beet	cabbage	onion
endive	celery	cauliflower	corn
romaine lettuce	pepper	rhubarb	cucumber
swiss chard	tobacco	carrot	strawberry
alfalfa		squash	

ORNAMENTALS

SENSITIVE		RESISTANT	
petunia	sweet basil	trees	orchids
mimulus	fuchsia	woody shrubs	coleus
snapdragon	impatiens	cactaceae	cyclamen
primrose	mint	anthurium	ivy
aster	ranunculus	bromiliad	narcissus
		calendula	lily
		camellia	portulaca
		carnation	most house plants

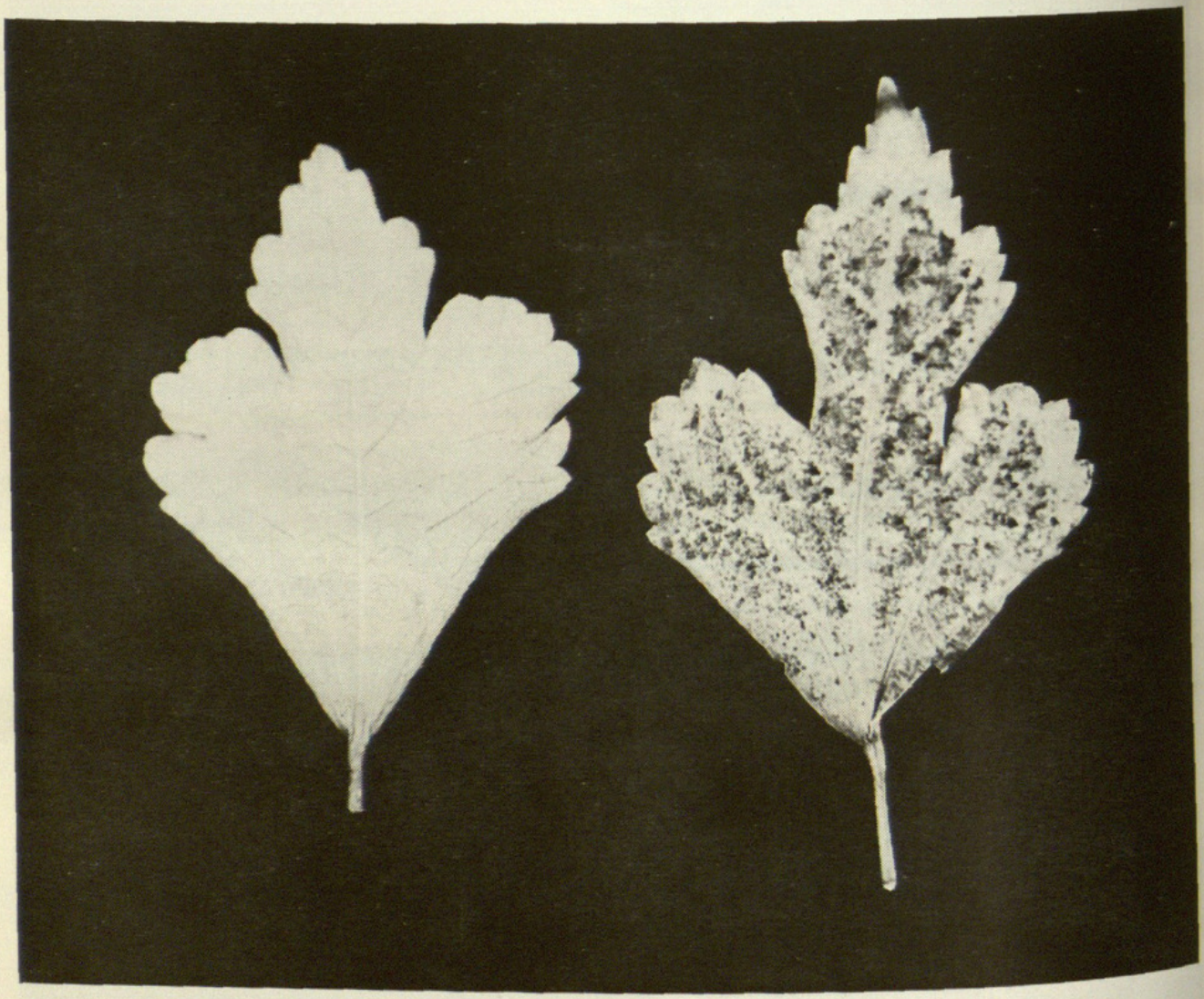
WEEDS

SENSITIVE

annual blue grass	cress
pigweed	jimson weed
chickweed	dock
wild oat	ground cherry
mustard	

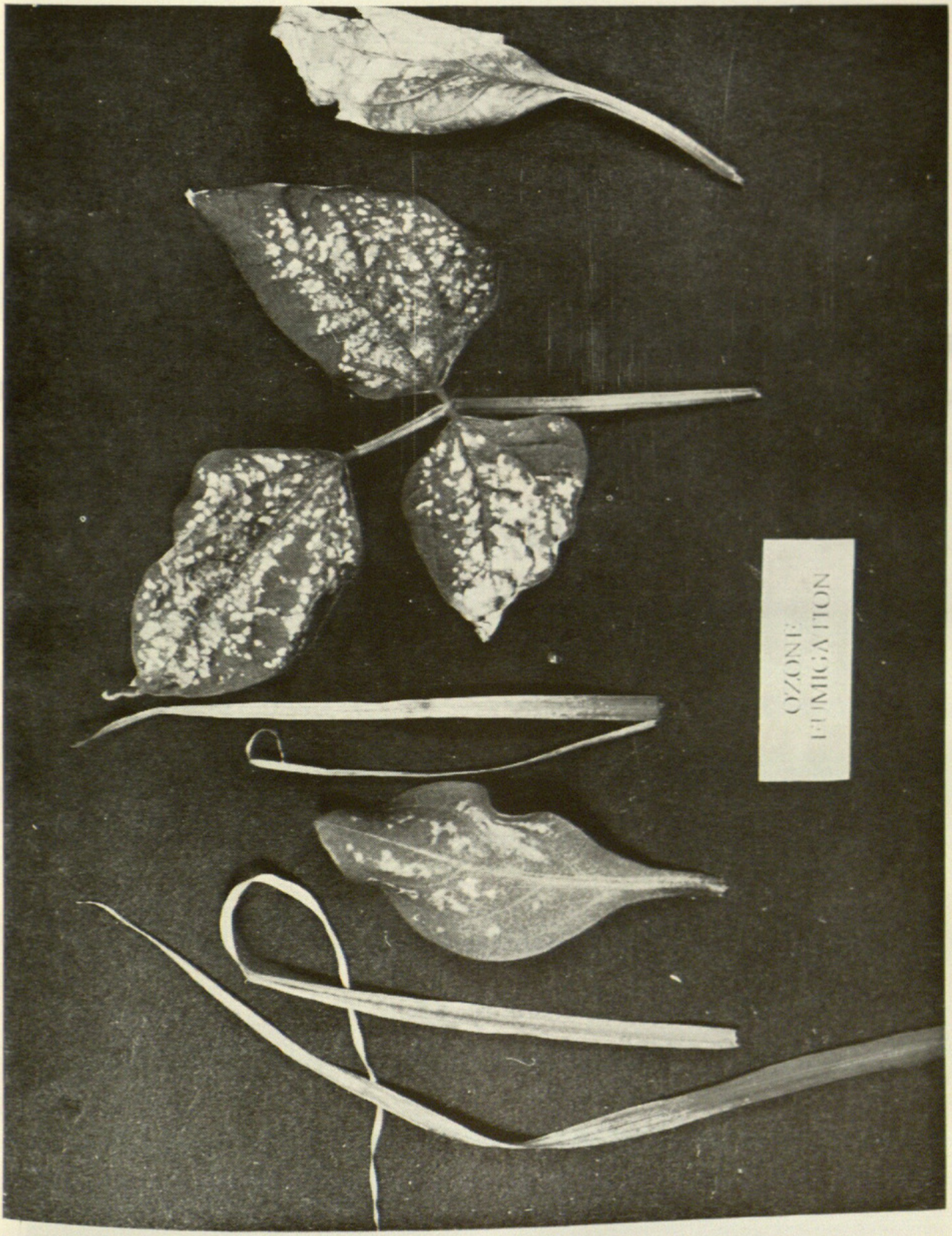
OZONE

Ozone, like PAN, is a product of the hydrocarbon—nitrogen oxide reaction in the sunlight. More ozone damage is being observed than was first suspected. This could be due to an increase in the amount of injury, a better knowledge of its symptoms or both. In higher concentrations it sometimes causes injury similar in some ways to that caused by PAN. However, this is not usual and may be distinguished easily by a careful observer.



Hibiscus syriacus. No injury is apparent on the lower surface while a heavy brown-black stipple attributed to ozone appears on the upper surface.

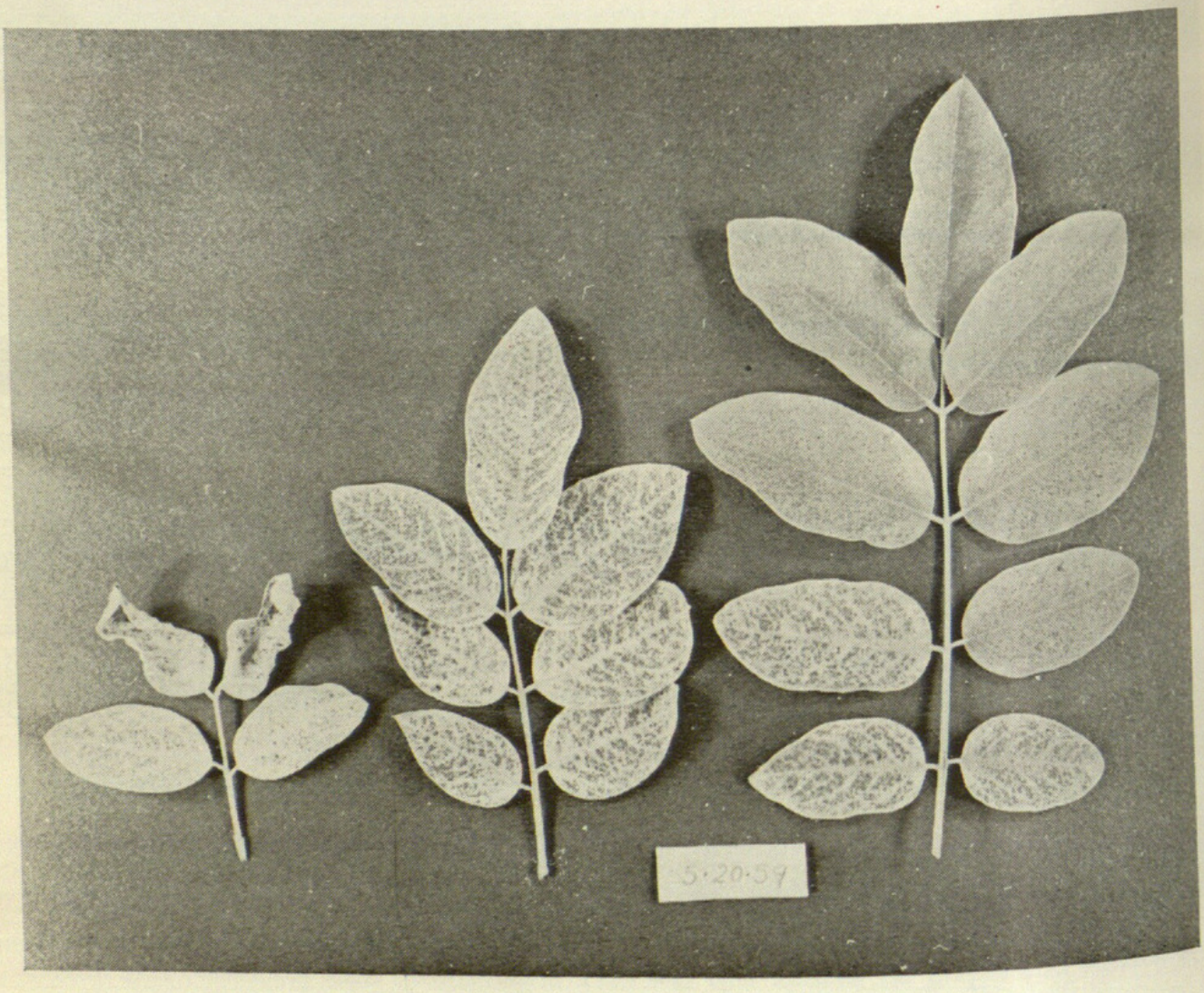
The chief distinction of ozone injury is that it primarily attacks the older leaves and particularly affects woody plants. In contrast to PAN, which attacks the lower leaf surface, ozone affects the palisade layer of the upper surface, causing small clusters of cells to darken and eventually turn brown-black. This was first noticed on grapes and studied by Richards. (4) Leaves thus affected turn yellow and drop prematurely.



Ozone damage caused by a heavy fumigation. Plants are oat, petunia. *Poa annua* (annual blue grass) pinto bean, and spinach. Damage is general to older leaves.

SOME OF THE COMMON PLANTS AFFECTED BY OZONE

alder
azalea
buttonwood
carob
elm
flowering maple
hibiscus
fibrous begonia
maple-leaf mulberry
orchid tree
sage
walnut
avocado
box elder
California allspice
nicotiana
chrysanthemum
fig
fuchsia
locust
maple (silver)
pepper tree
sycamore
willow
morning glory



Ozone stipple on red locust. The more severely damaged older leaves were yellow in May and were beginning to drop.

MELALEUCA LINARIIFOLIA

Melaleuca linariifolia

ARBORETUM INTRODUCTION — 1960

Common Name	:	Flax leaf Paperbark
Scientific Name	:	*Melaleuca linariifolia,* J. E. Smith, Trans. Linn. Soc. London 3:278. 1797; Exot. Bot. 1:109. pl. 56. 1805.
Family	:	Myrtaceae
Origin	:	New South Wales and Queensland, Australia
Form	:	Tree—10-30 feet
Flowers	:	Showy white fluffy-flowers in profusion in May and June
Foliage	:	Narrow oval to 1 inch long—evergreen
Growth Rate	:	Rapid—2-3 feet per year
Soil Requirement	:	Tolerant of variety of soils but grows best in medium loam
Exposure	:	Full sun
Temperature Tolerance	:	To 25°—possibly less
Water Needs	:	Moderate to heavy depending on soil (Plant comes from swampy areas)
Pruning	:	Only what is necessary to form tree or remove dead wood. Occasional shortening of long branches reduces chance of breaking in high winds
Pests	:	None of record
Disease	:	None of record
Propagation	:	Seed—germinates readily in about 10 days
Remarks	:	A very showy tree when in bloom and pleasing in appearance when not in bloom. The bark is papery and flakes off in strips. It is very attractive.

January 22, 1965

To the Editor:

I've watched with interest the developing use of color in Lasca Leaves, but the innovation in the October issue of 1964, recently received, invites some criticism. I hope the following comments are in order and that some alteration in editorial policy can be made before the family of errors is repeated.

The insert is lovely and the idea is good. However, it has no pagination and therefore can not be cited in further scientific publications. Although the color insert repeats the cover, in our copy the color reproduction is actually better on the insert than on the cover. The cover carries the common name but not the scientific name given on the insert. The explanation of the cover (inside front cover) repeats the common name, as does the table of contents. Consider your future reader who lacks the insert someone placed on the "potting shed wall" and now can not identify by scientific name the cover of Vol. VIX, No. 4. To keep friends remember it is the Republic of South Africa, not the 'Union of'. On the insert: the generic name is *Osteospermum.* The Scientific or Latin name is *Osteospermum fruiticosum* (L.) Norlindh. The reference to "Supp XI Kew. 173," is without any meaning. Norlindh (note no period, that is his name) made the combination in his Studies of Calendula, not in the supplement of Index Kewensis. According to Index Kewensis, Lessing did not make the combination in *Dimorphotheca,* De Candolle did. I won't add many more to your woes—just that the index carries no reference to the good color which I hope remains a feature of Lasca Leaves.

I'm sympathetic to the problem of keeping editorial consistency in such a magazine, but I hope all of us try to give the public the correct botanical names properly used.

Sincerely,

(Signed) RICHARD A. HOWARD, *Director*

The Arnold Arboretum, Cambridge, Massachusetts

Thank you, Dr. Howard, for your constructive criticisms.—Ed.

ETHYLENE

Ethylene is a simple, unreacted hydrocarbon of lower molecular weight and, unlike PAN and ozone, is not easily removed by carbon filters. Ethylene injury has been known for many years (5), but only two plants have shown serious symptoms: orchids and carnations. One instance of injury to peas has been observed at the California Institute of Technology. One of the few pollutants which affects the blossom, this gas causes what is known as dry sepal on orchids. The sepals age prematurely and, in severe cases, even turn brown before the bud opens. Losses to orchid growers are quite severe and many have left the area or have moved in from the coastal areas where injury is most severe. Ethylene is one of the major problems in the San Francisco region where many orchids are grown.

Injury to carnations is not very common. It is, however, strange. The opened blossom reverts back to a bud, an effect called "sleepiness".

Ethylene causes peculiar effects on plants other than orchid and carnation and many have been described by Crocker. (5) However, with the single exception of peas, none has been observed in this area.

HYDROGEN FLUORIDE

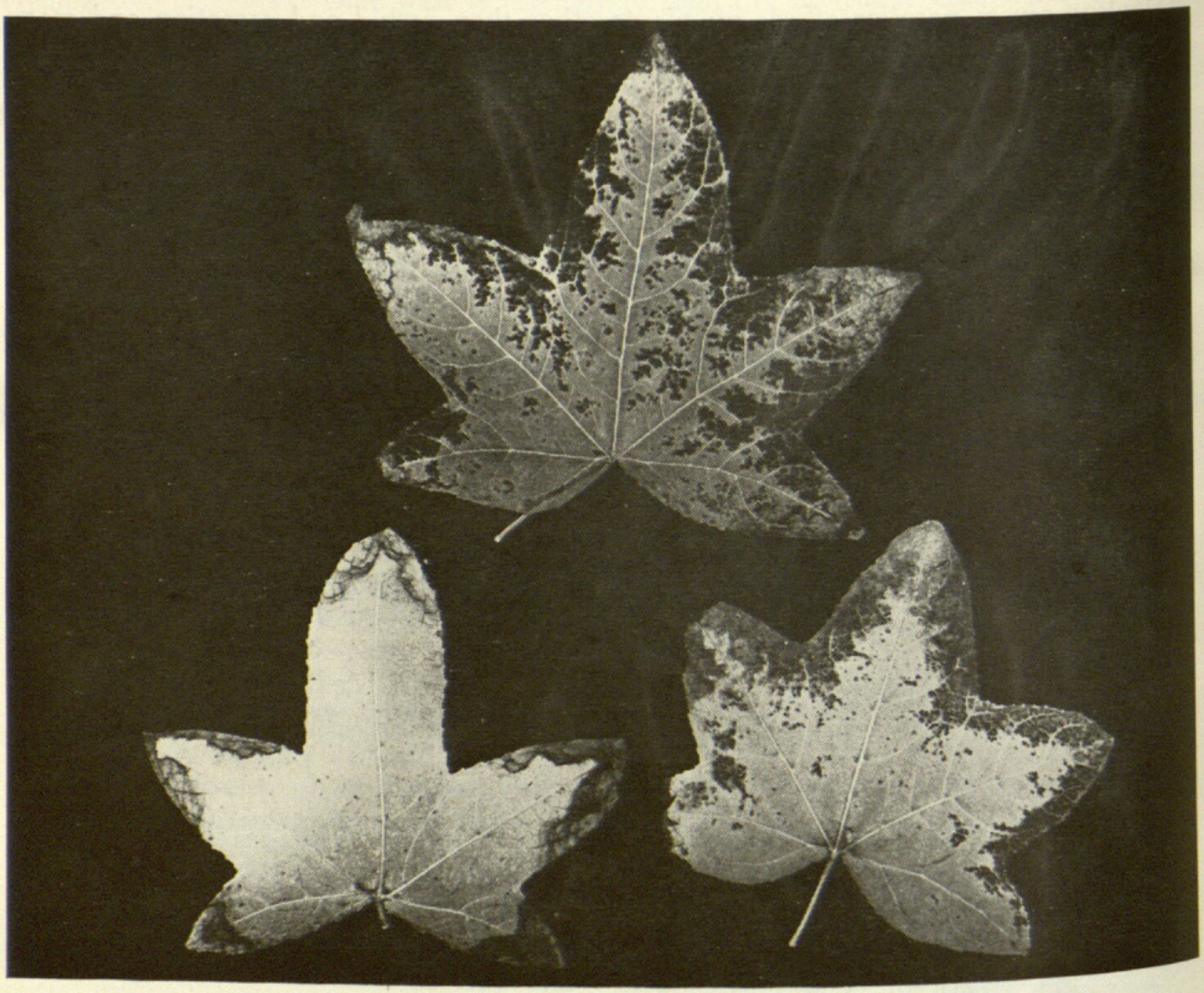
Yucca with dark brown marginal and tip injury typical of fluorine.

Fluoride damage is less common in the Los Angeles basin than in many other industrial areas since few major industries here produce this pollutant. However, a number of ceramic plants cause local injury to vegetation. Fluoride gases are released when clays and frits are heated to high temperatures. These compounds are cumulative when absorbed by plants and are translocated within the plant, concentrating in the tips and edges of the leaves. There they cause a cocoa brown discoloration with well defined borders. Very low concentrations over an extended period of time are therefore capable of causing severe damage near the source. Many plants are affected by these gases and extensive lists of sensitivity have been published. (6).

The list which follows include a few on which lamage has been observed in Southern California:

PLANTS SENSITIVE TO HYDROGEN FLUORIDE

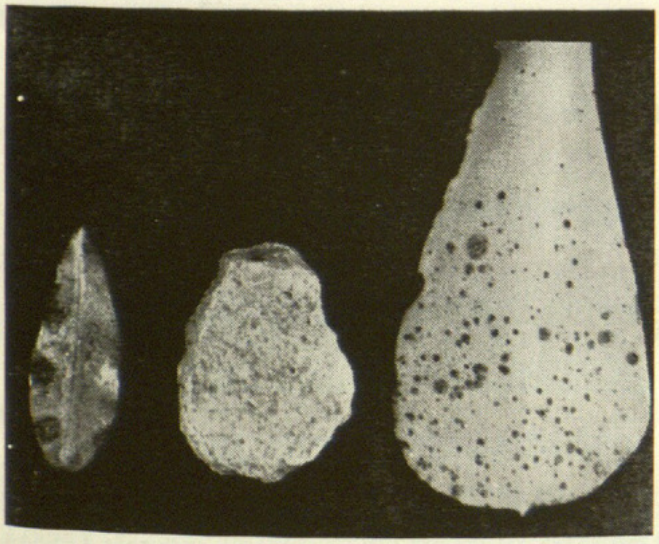
gladiola	yucca
Monterey pine	iris
elm	magnolia
viburnum	rose
ficus	papyrus
pear	mahoberberis
apricot	strawberry
peach	grape
tomato	eucalyptus
sunflower	bottle brush



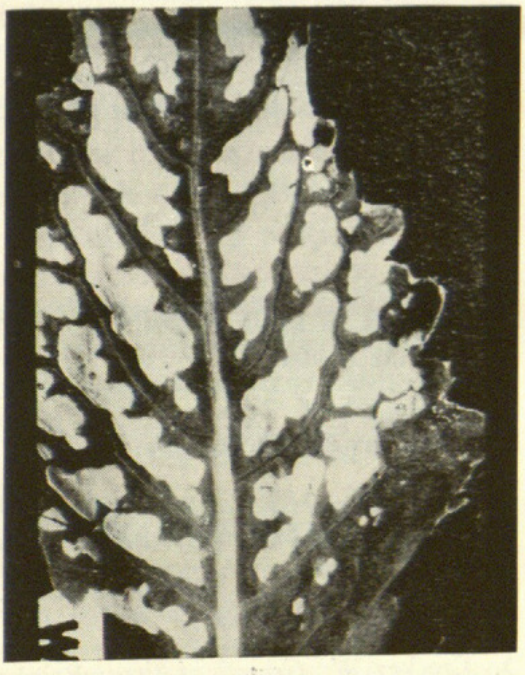
Liquidambar leaves affected by fluoride.

SULPHUR DIOXIDE

Sulfur dioxide concentrations in the Los Angeles area are low for a large industrial center. Plant damage from this cause is therefore very light and normally occurs only in case of an accident in an industrial plant where this gas is used. In these few instances, only a small area around the source is affected. Acute injury appears as a tan to paper white area between the veins, with most severe symptoms appearing on the younger leaves. On a few occasions sulfur dioxide injury has coincided with that caused by PAN and ozone, thus producing severe damage whose cause was difficult to determine from plant observations alone. Since this injury is so rare here, we will refer the reader to other sources for more comprehensive lists (6, 7) of sensitive plants and name only the following: alfalfa, spinach, squash, oat, sweet pea, aster, mustard, endive, and clover.



"Aerosol" injury to two leaves and spots on a white rock from outdoor planter. Found in the vicinity of a plant burning heavy residual fuel oil containing sulfur.



Sulphur dioxide damage to a mustard leaf. (Enlarged) Injury appears as completely bleached areas between the veins which stand out dark green.

"AEROSOLS"

The term "aerosol" as used here is actually a misnomer, since these particles or drops are much too large to be so described. However, they have been referred to as such in the past and it is difficult to change the term. These droplets are found in the immediate vicinity of all industrial plants which consume large quantities of heavy residual fuel oil containing considerable amounts of sulfur. They are larger near the source, becoming much smaller at around ½ mile and disappearing within 1 to 1½ miles. Their exact composition has not been completely determined, but they usually contain small, round, sponge-like carbonaceous particles known as cenosphere and, in one instance, an analysis of the residue showed the presence of a considerable amount of iron and a small amount of vanadium.

These droplets will burn holes in leaves and blossoms, in canvas and paint, and will stain white rocks used in outdoor planters. No valid sensitivity list can be given for this type of injury; however, it has been noted that waxy leaves, such as those of a rubber tree or camellia, seem to be less affected.

NOTE: The author wishes to recognize the assistance of Michelle Terry in the study of aerosols.

NITROGEN OXIDES

At the present time, not very much is known about the effect of these gases. It is well known that levels of nitric oxide and of nitrogen dioxide are frequently high in large cities, concentrations of the former often exceeding one part per million. Since these gases are formed in any high combustion process they are very difficult to control. Glater (8) has made some study of this problem and attributes to this cause at least part of the premature aging seen on much vegetation.

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2. Noble, W. M. *The Pattern of Damage Produced on Vegetation by Smog.* Agriculture and Food Chemistry 8: 330-332 (1955).
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5. Crocker, W., *Growth of Plants.* Reinhold, 1948.
6. Thomas, M. D. *Effects of Air Pollution on Plants.* World Health Organization: Monograph No. 46, pp 233-279, Geneva (1961).
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8. Bush, A. F., R. A. Glater, J. Dyer, G. Richards. *The Effects of Engine Exhaust on the Atmosphere when Automobiles are Equipped with Afterburners.* Report No. 62-63, Department of Engineering, University of California at Los Angeles (1962).

NOTE: Space does not permit this subject of pollutants to be as complete as many readers might desire. We therefore wish to recommend the chapter on "The Effects of Air Pollution on Plants" by Moyer D. Thomas in the World Health Organization Monograph Series, No. 46, the subject of which is Air Pollution. This is a comprehensive review in simple language, with excellent illustrations in color, by an outstanding authority in this field.