

PHOTOGRAPHS OF ORNAMENTALS
FOR WHICH

NO SMOG INJURY

SEEN AFTER GROWING 7 MONTHS
IN AMBIENT AIR POLLUTION

LOS ANGELES STATE AND COUNTY ARBORETUM, ARCADIA 1990-91

RESPONSE TO AMBIENT AIR POLLUTION:
NO INJURY SYMPTOMS SEEN, APRIL-OCTOBER

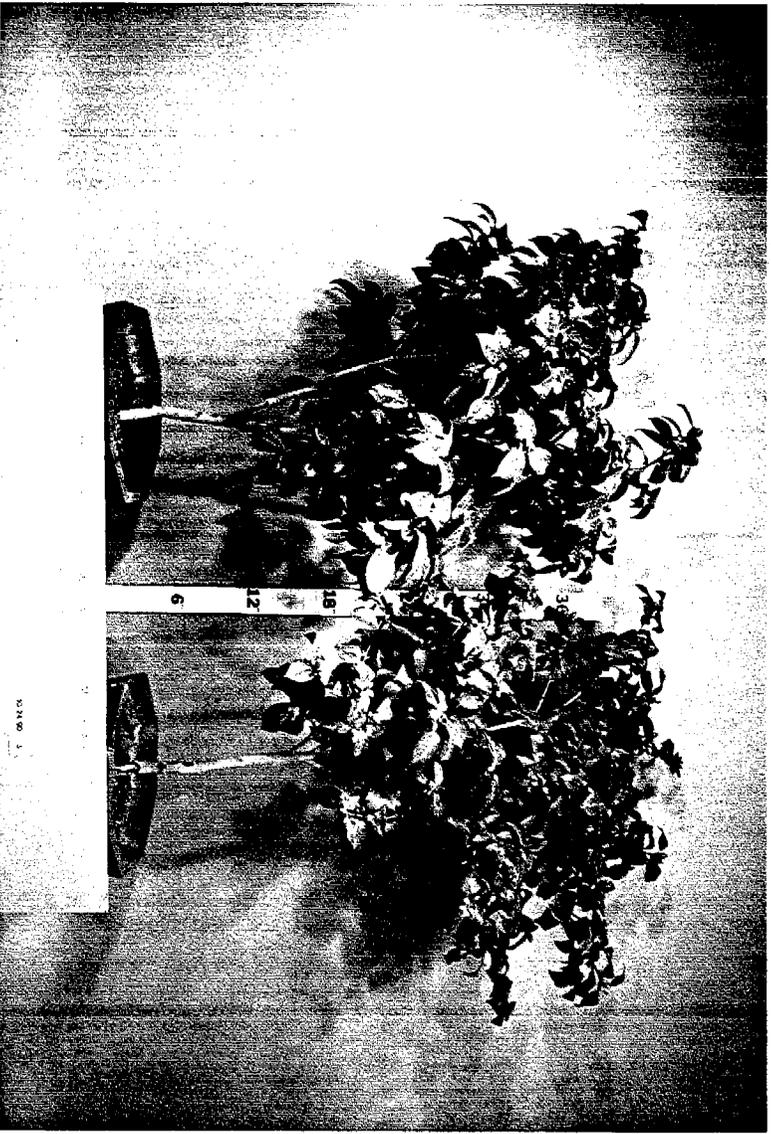
SCIENTIFIC NAME	COMMON NAME
<i>Camellia japonica</i>	CAMELLIA
<i>Eucalyptus sideroxylon rosea</i>	PINK IRON BARK
<i>Feijoa sellowiana</i>	PINEAPPLE GUAVA
<i>Juniperus chinensis</i>	PFITZER JUNIPER
<i>Magnolia grandiflora</i>	SOUTHERN MAGNOLIA
<i>Nerium oleander</i>	OLEANDER
<i>Pelargonium vulgare</i>	MARTHA WASHINGTON
<i>Pelargonium vulgare</i>	GERANIUM
<i>Podocarpus macrophyllis</i>	YEW PINE
<i>Rhapiolepis indica</i>	INDIAN HAWTHORN
<i>Tulbaghia violacea</i>	SOCIETY GARLIC

LOS ANGELES STATE AND COUNTY ARBORETUM, ARCADIA 90-91

NO SMOG INJURY SEEN

CAMELLIA

Camellia japonica



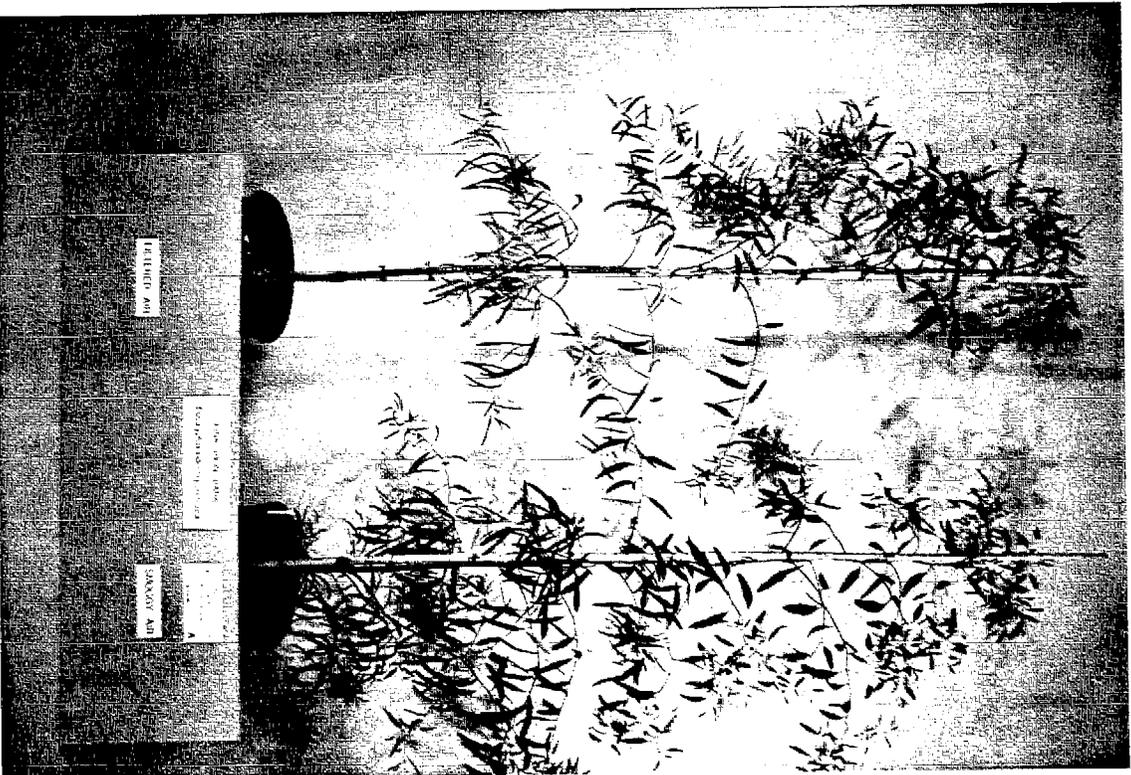
NO SMOG INJURY SEEN

180

PINK IRON BARK

Eucalyptus

sideroxylon rosea



NO SMOG INJURY SEEN

PINAPPLE GUAVA

Feijoa Sellowiana



NO SMOGG INJURY SEEN

PFITZER JUNIPER
Juniperus chinensis



NO SMOG INJURY SEEN

MAGNOLIA

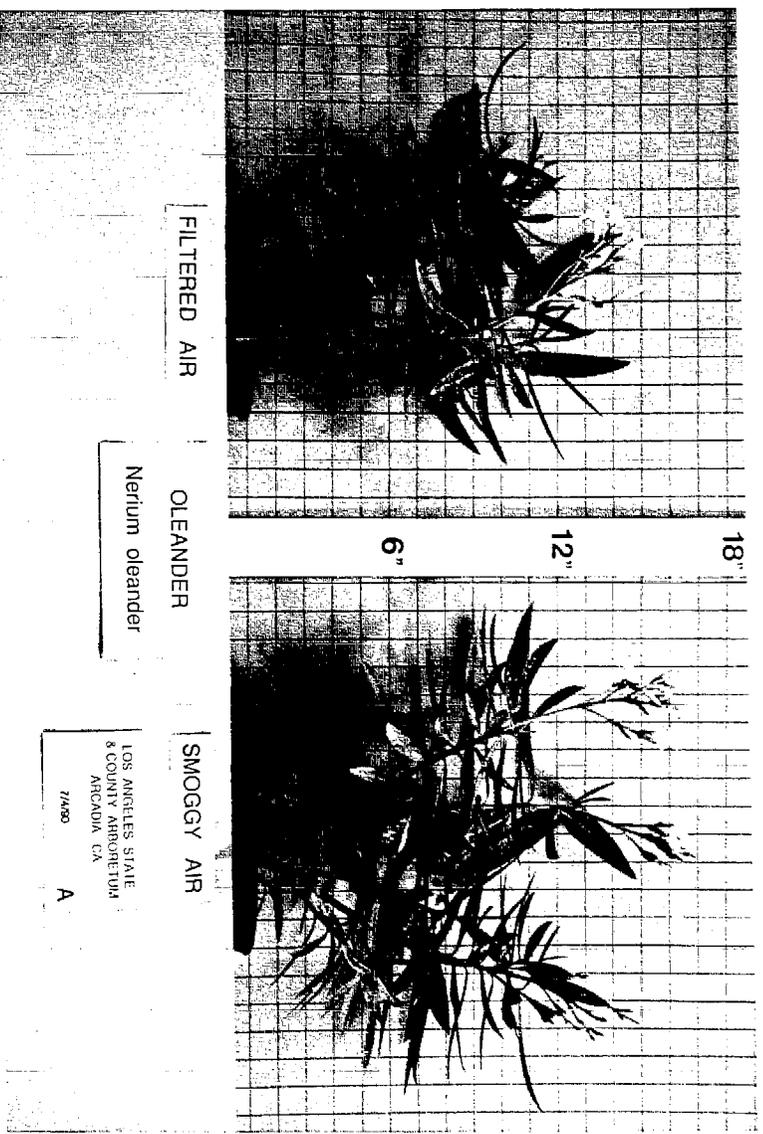
Magnolia grandiflora



NO SMOGG INJURY SEEN

OLEANDER

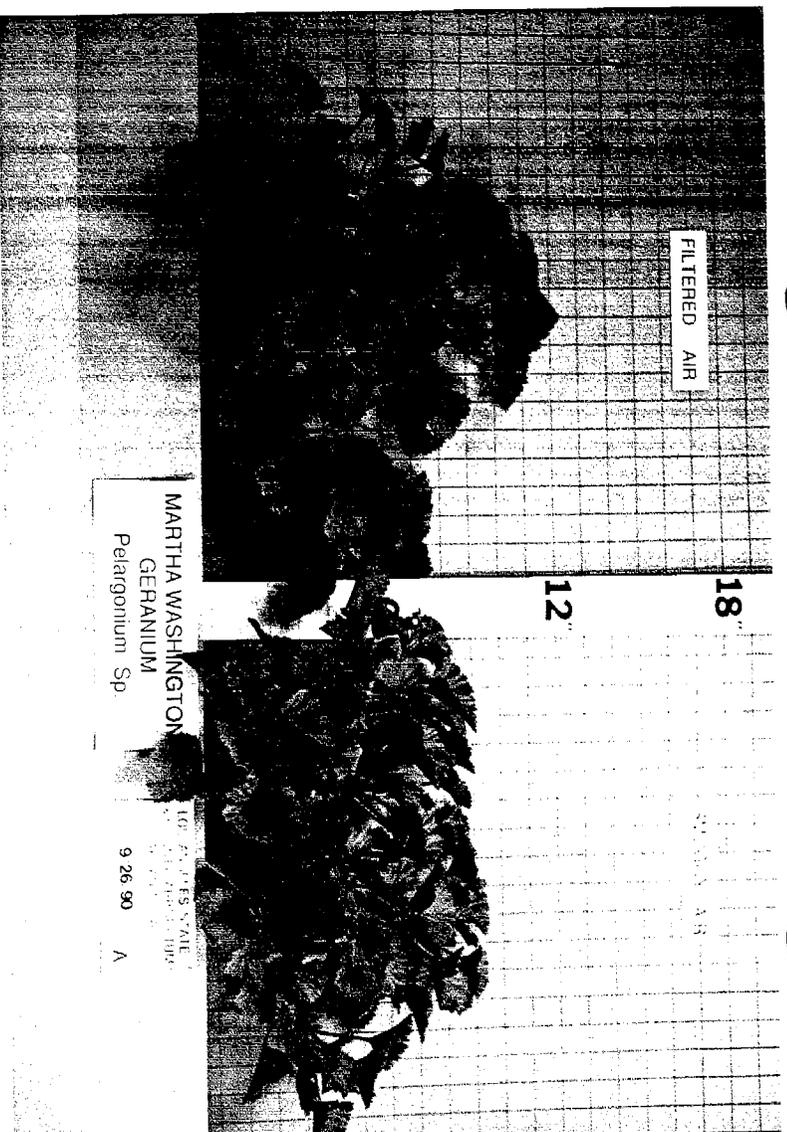
Nerium oleander



NO SMOG INJURY SEEN

MARTHA WASHINGTON

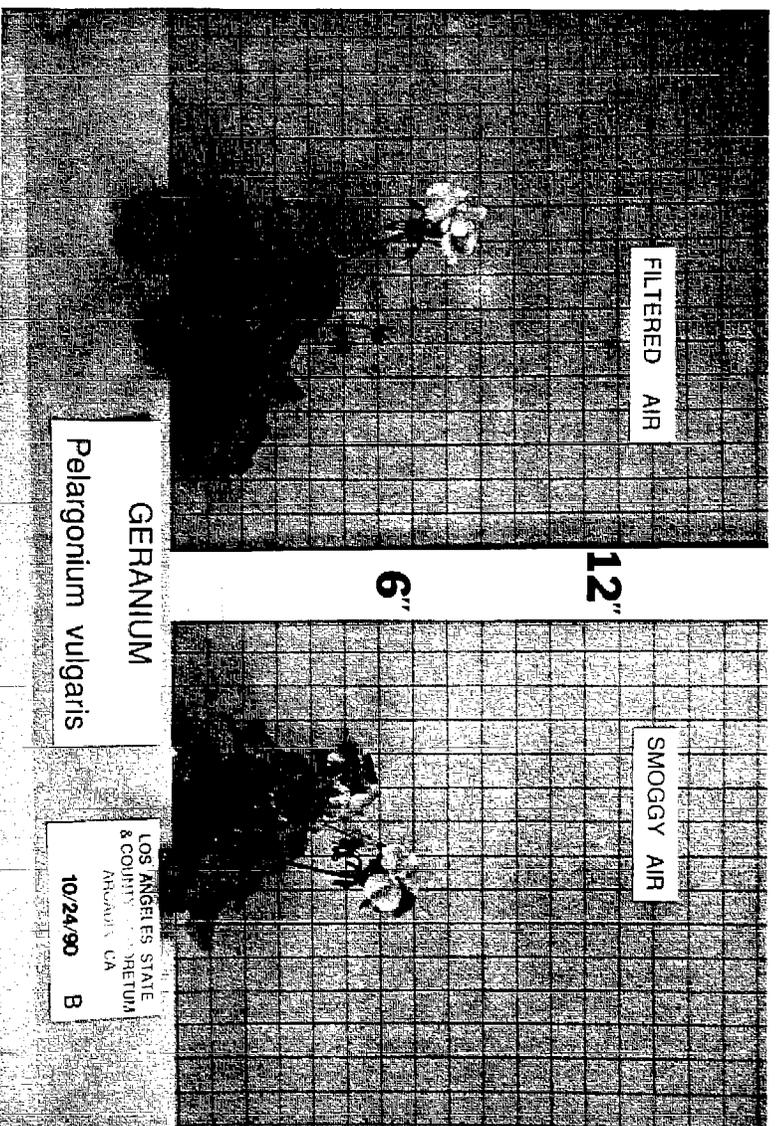
Pelargonium vulgare



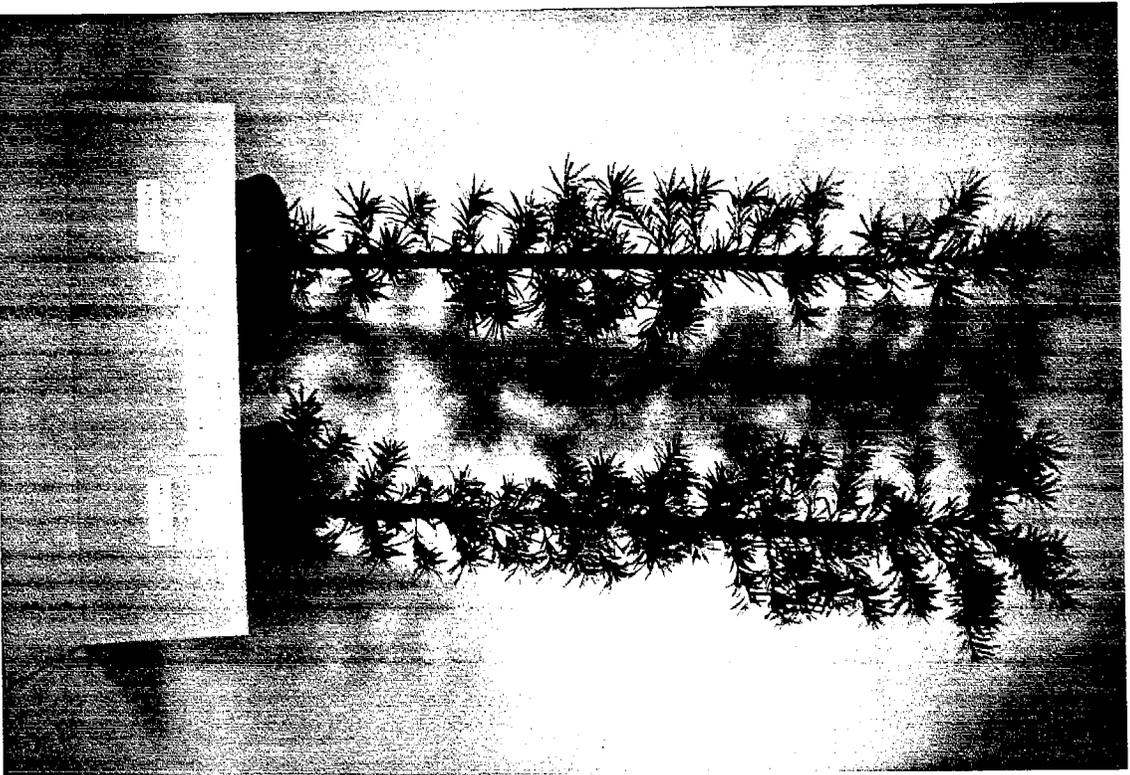
NO SMOGG INJURY SEEN

GERANIUM

Pelargonium vulgare

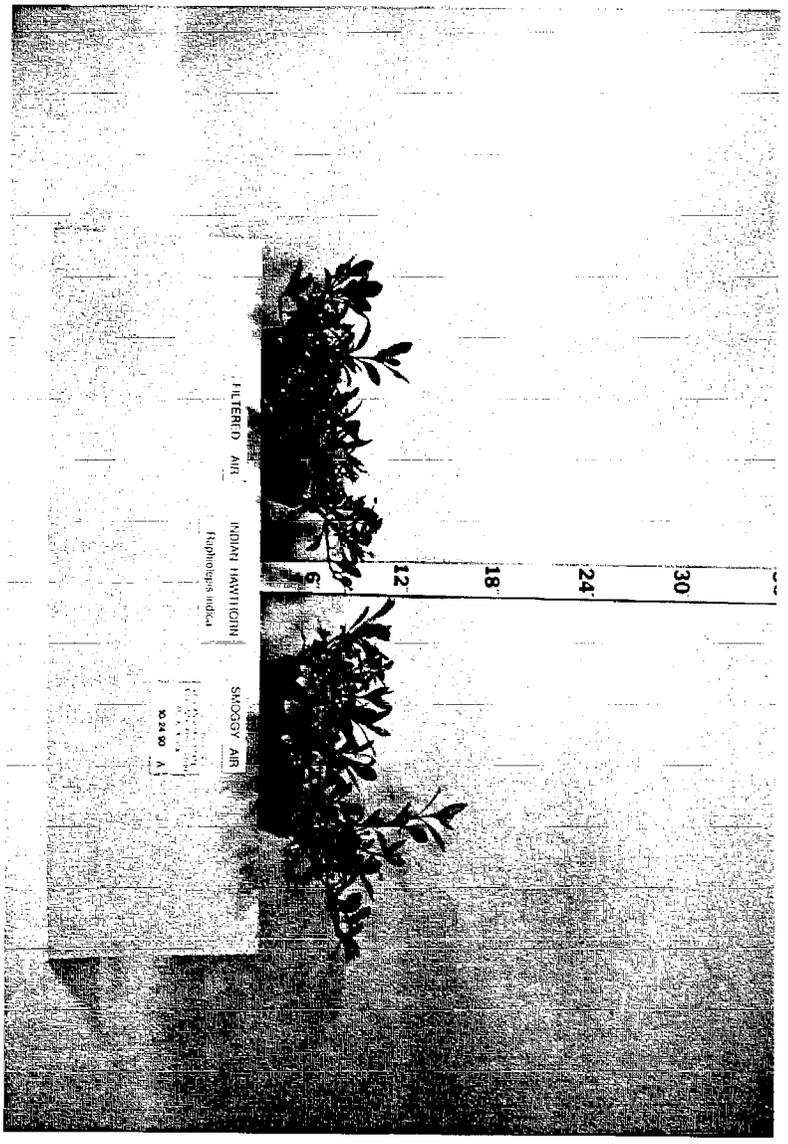


NO SMOG INJURY SEEN



YEW PINE
Podocarpus
macrophyllis

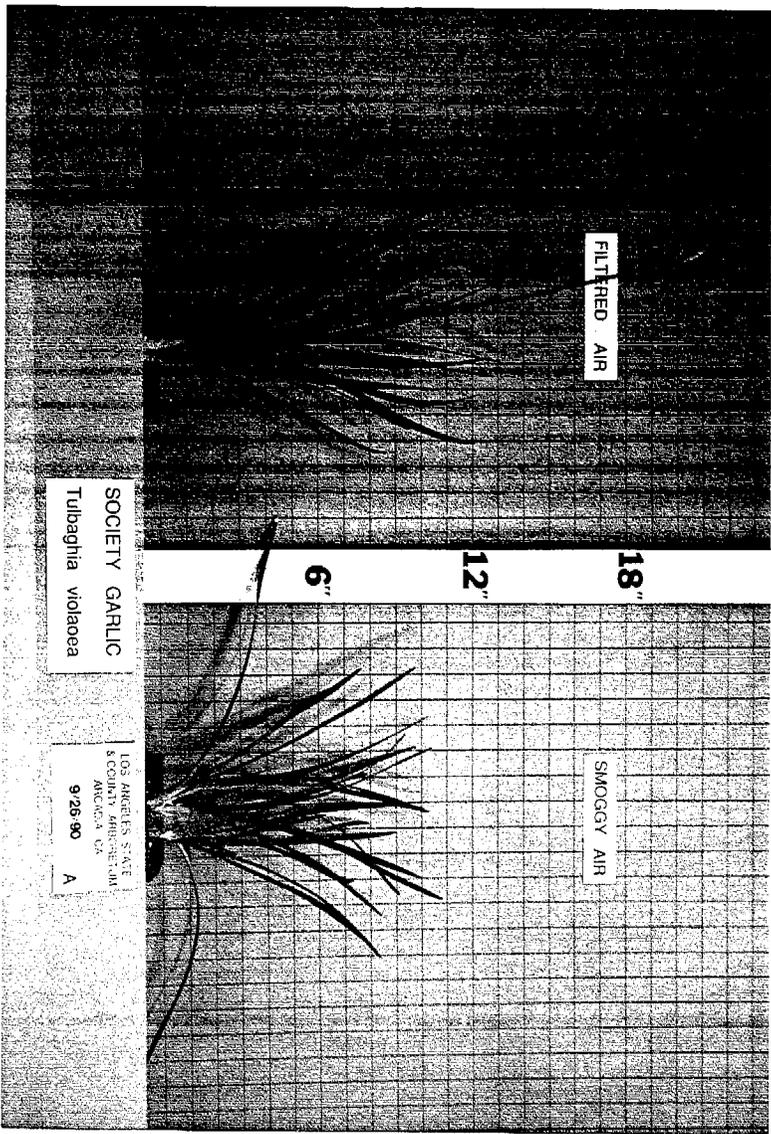
NO SMOG INJURY SEEN INDIAN HAWTHORN *Rhaphiolepis indica*



NO SMOGG INJURY SEEN

SOCIETY GARLIC

Tulbaghia violaoea



SERIES OF PHOTOGRAPHS
SHOWING HOW AIR POLLUTION

REDUCES GROWTH:

ASPLENIUM BULBIFERUM (Mother Fern)

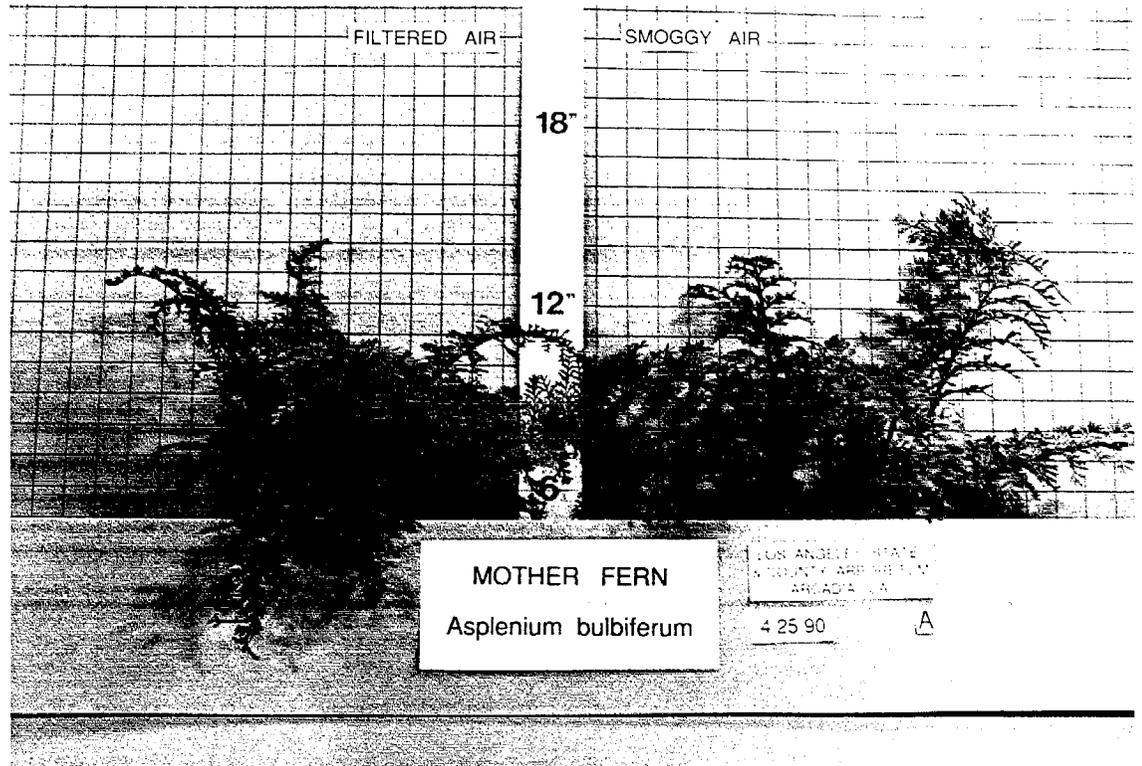
4/25/90 to 10/24/90

LOS ANGELES STATE AND COUNTY ARBORETUM, ARCADIA, 1990-91

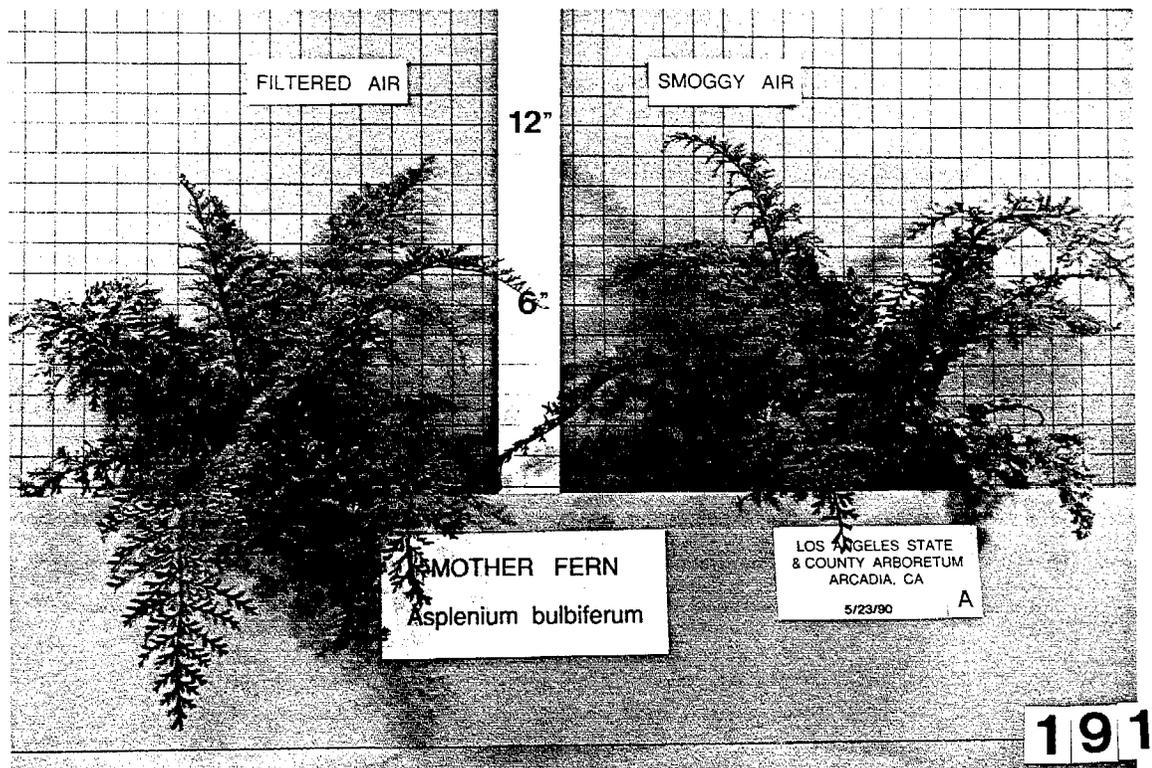
GROWTH REDUCTION SERIES

ASPLENIUM BULBIFERNUM (Mother Fern)

4/25/90



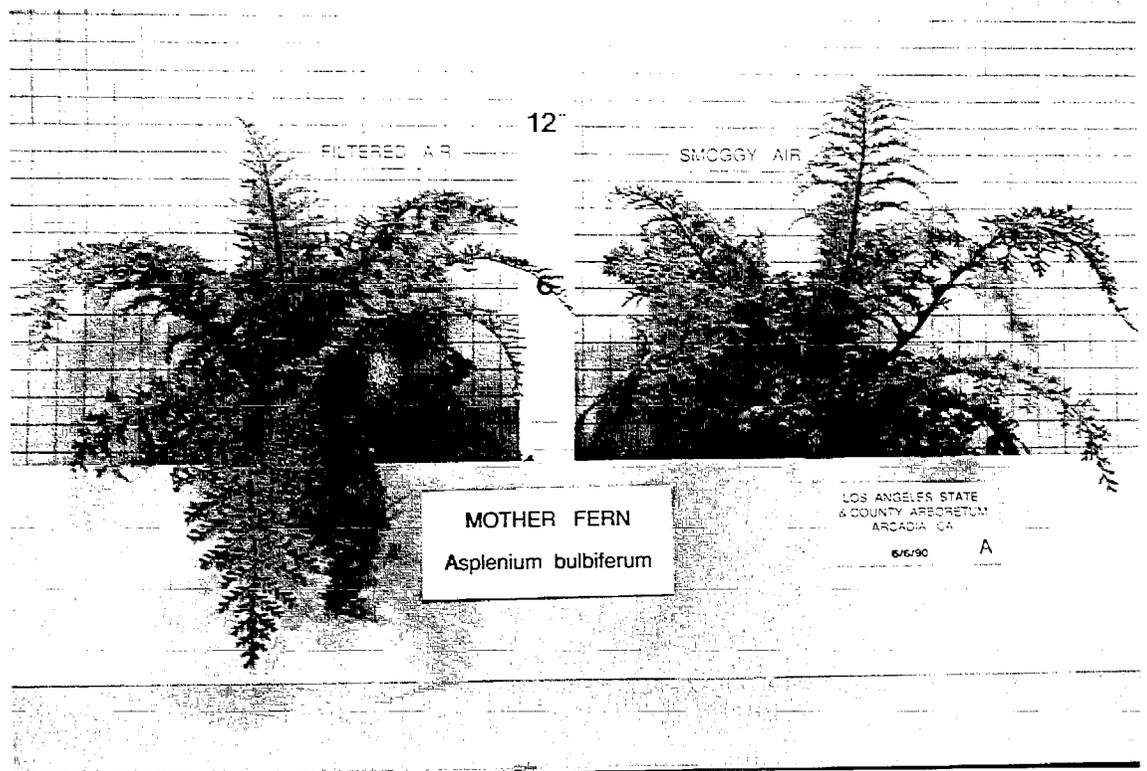
5/23/90



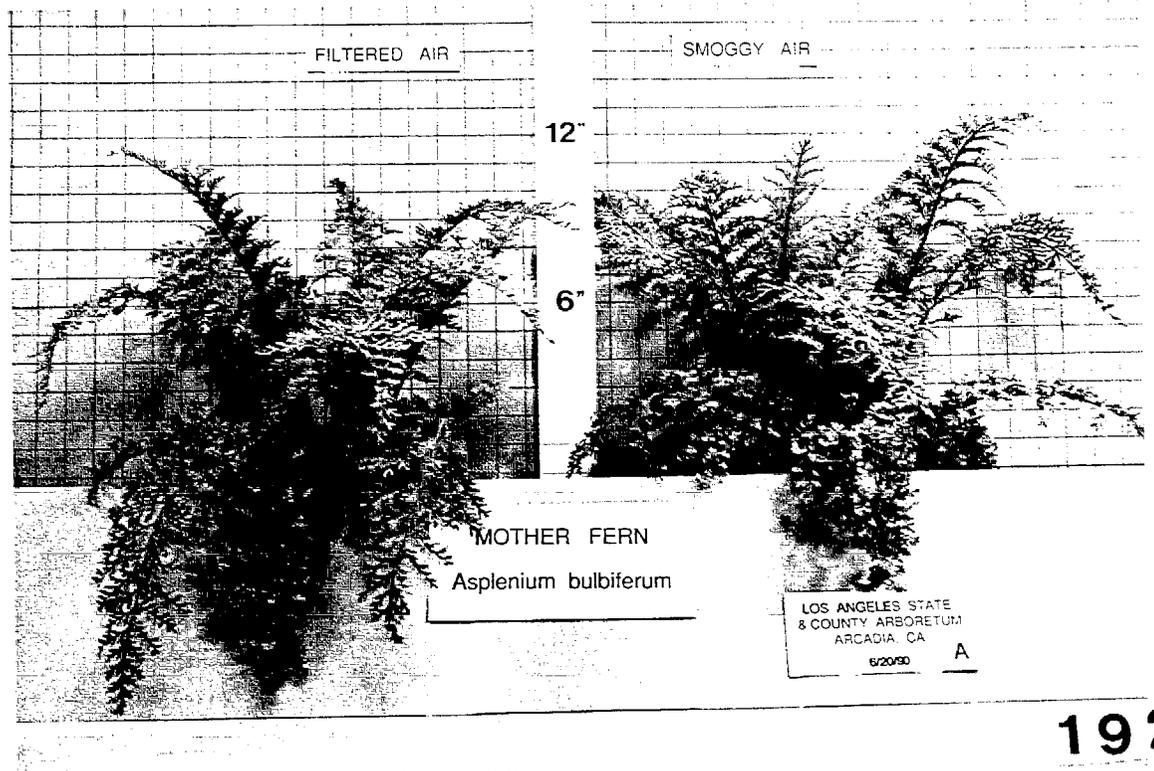
GROWTH REDUCTION SERIES

ASPLENIUM BULBIFERNUM (Mother Fern)

6/6/90



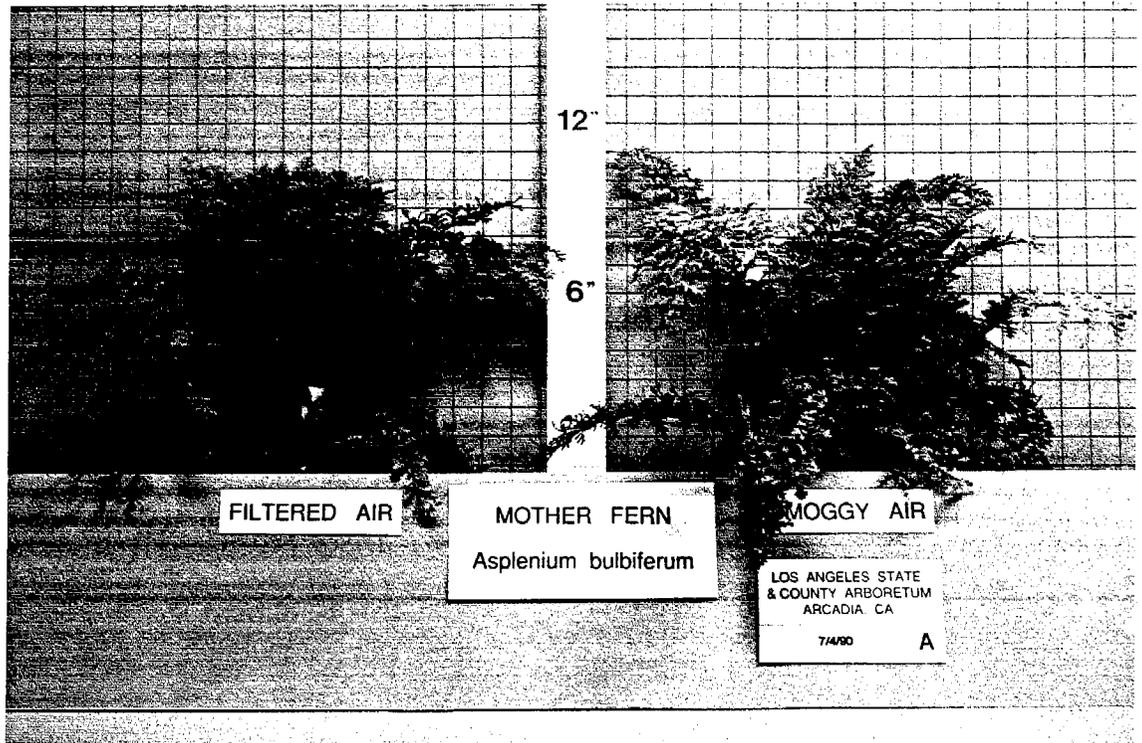
6/20/90



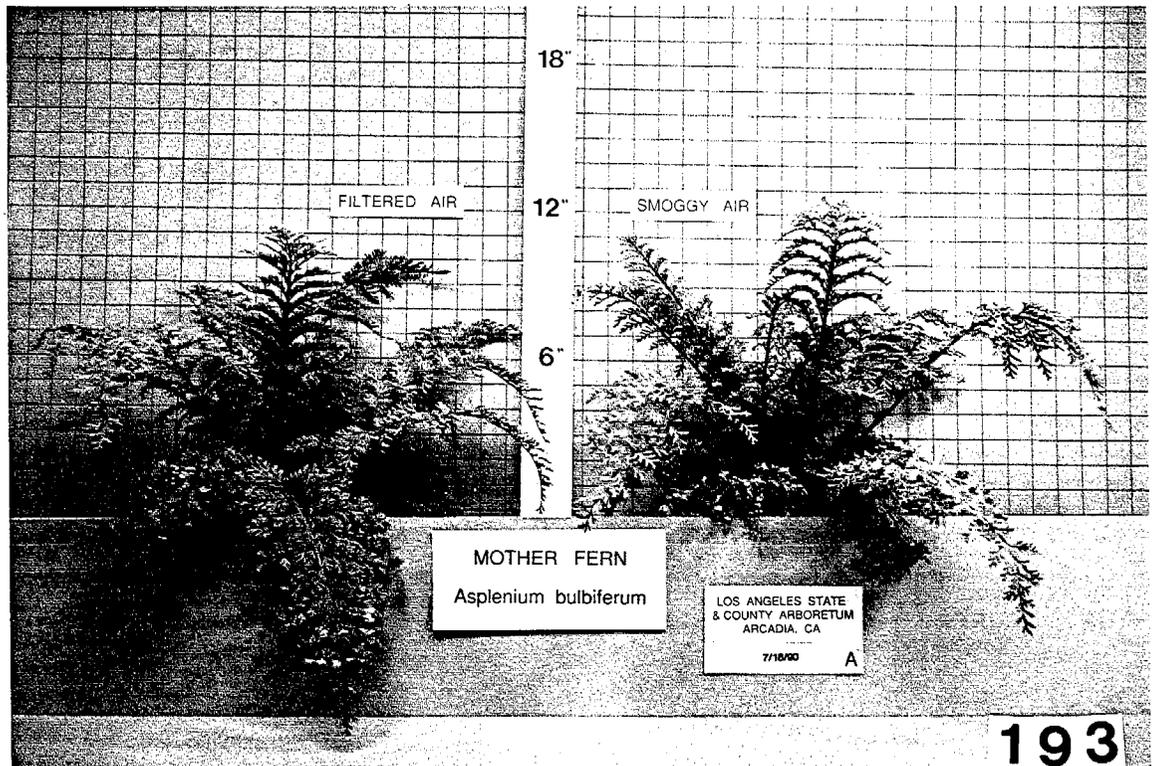
GROWTH REDUCTION SERIES

ASPLENIUM BULBIFERNUM (Mother Fern)

7/4/90



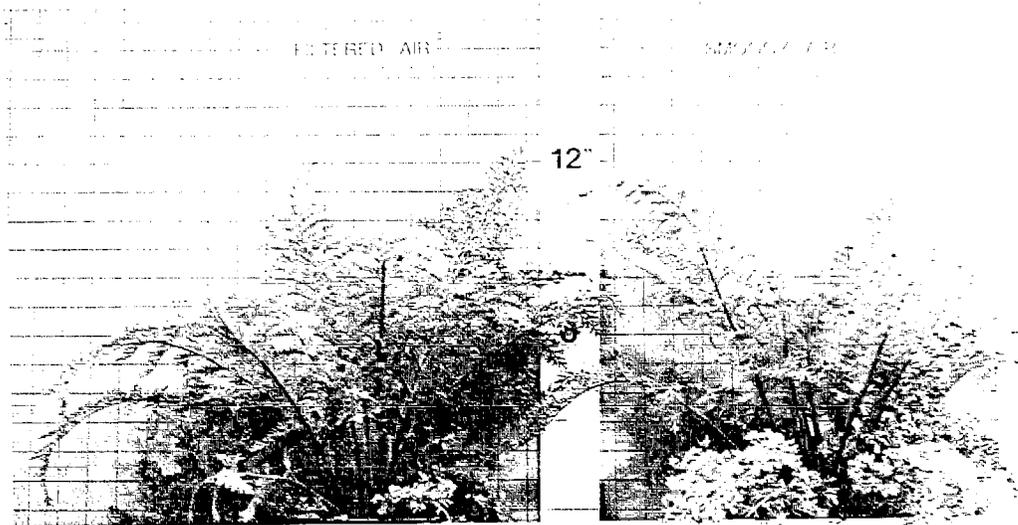
7/18/90



GROWTH REDUCTION SERIES

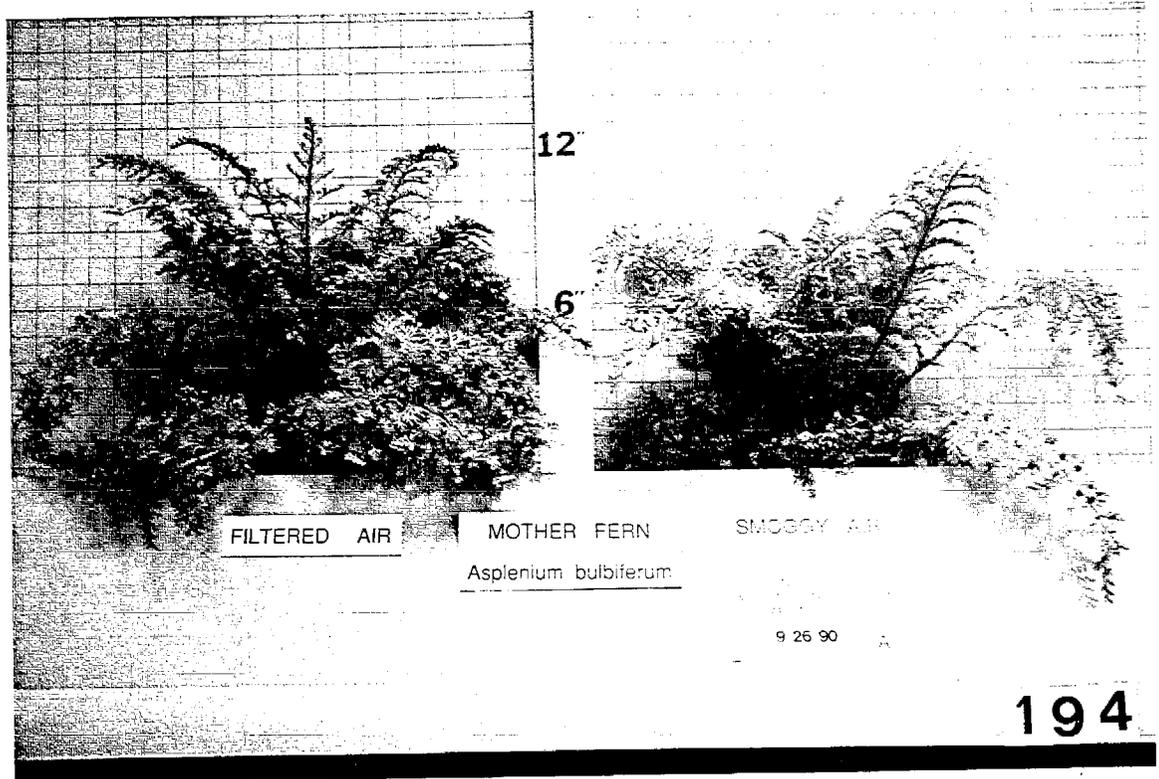
ASPLENIUM BULBIFERNUM (Mother Fern)

8/1/90



MOTHER FERN
Asplenium bulbiferum

9/26/90



FILTERED AIR

MOTHER FERN
Asplenium bulbiferum

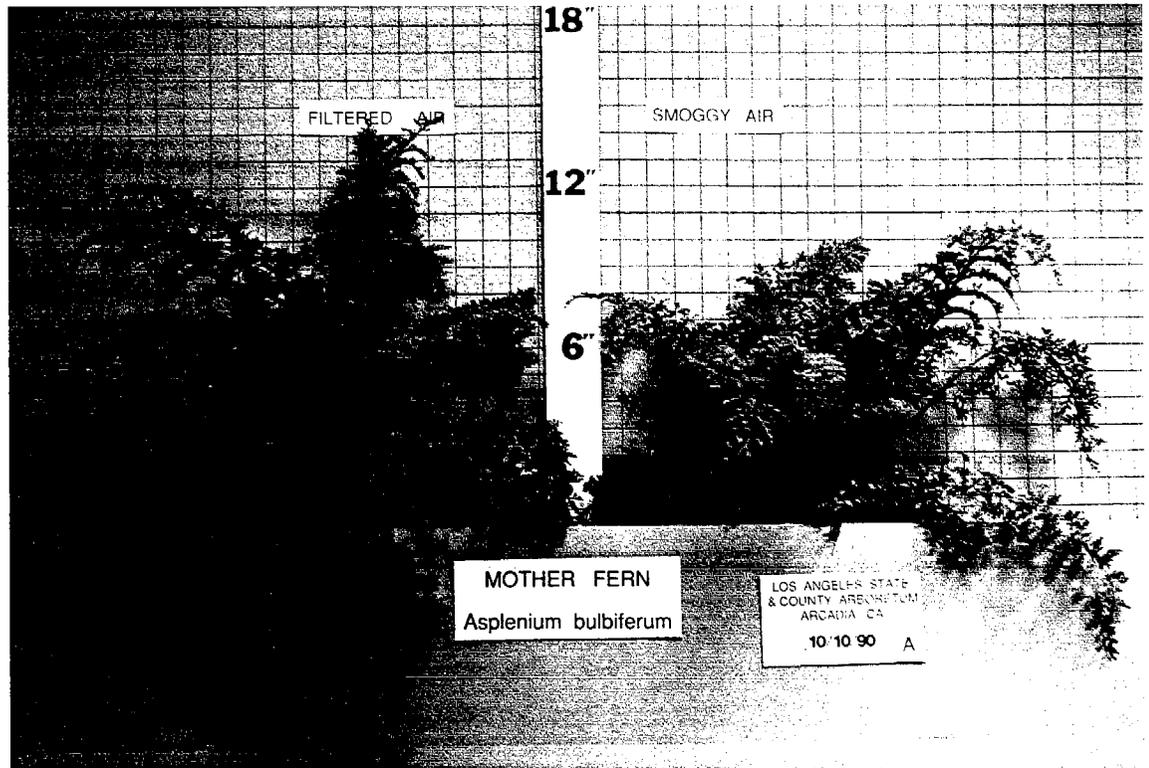
SMOBBY AIR

9 26 90

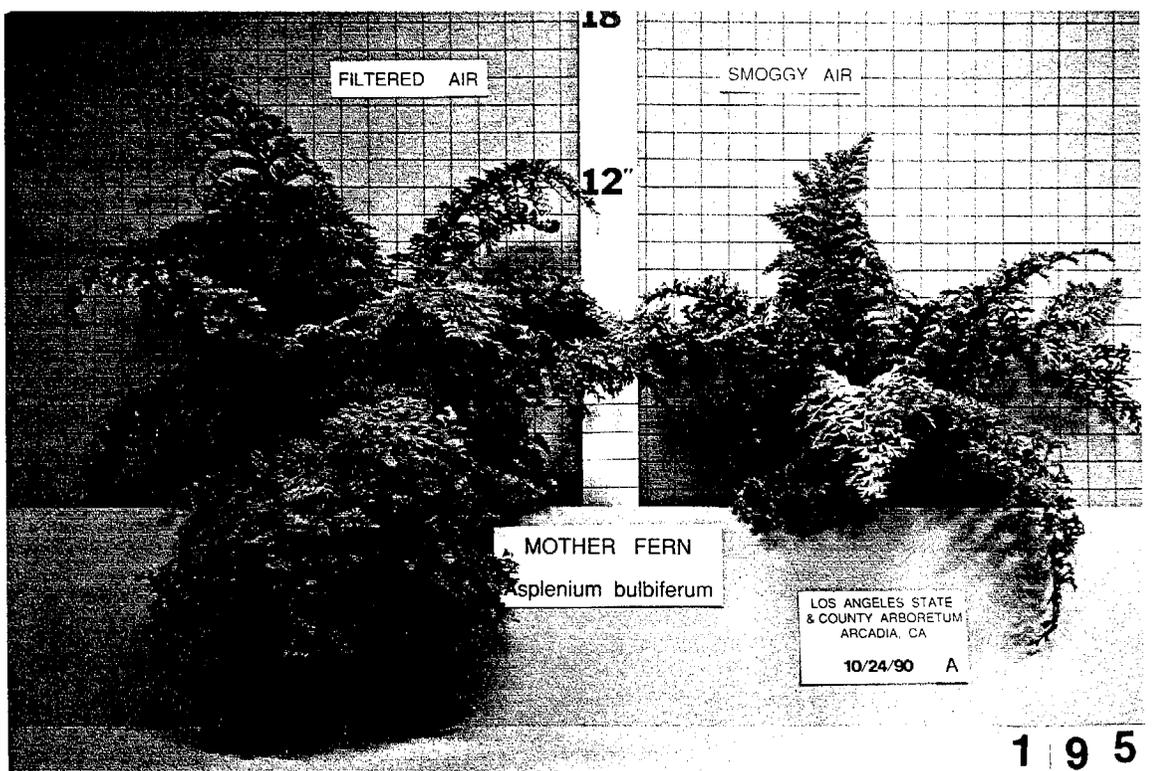
GROWTH REDUCTION SERIES

ASPLENIUM BULBIFERNUM (Mother Fern)

10/10/90



10/24/90



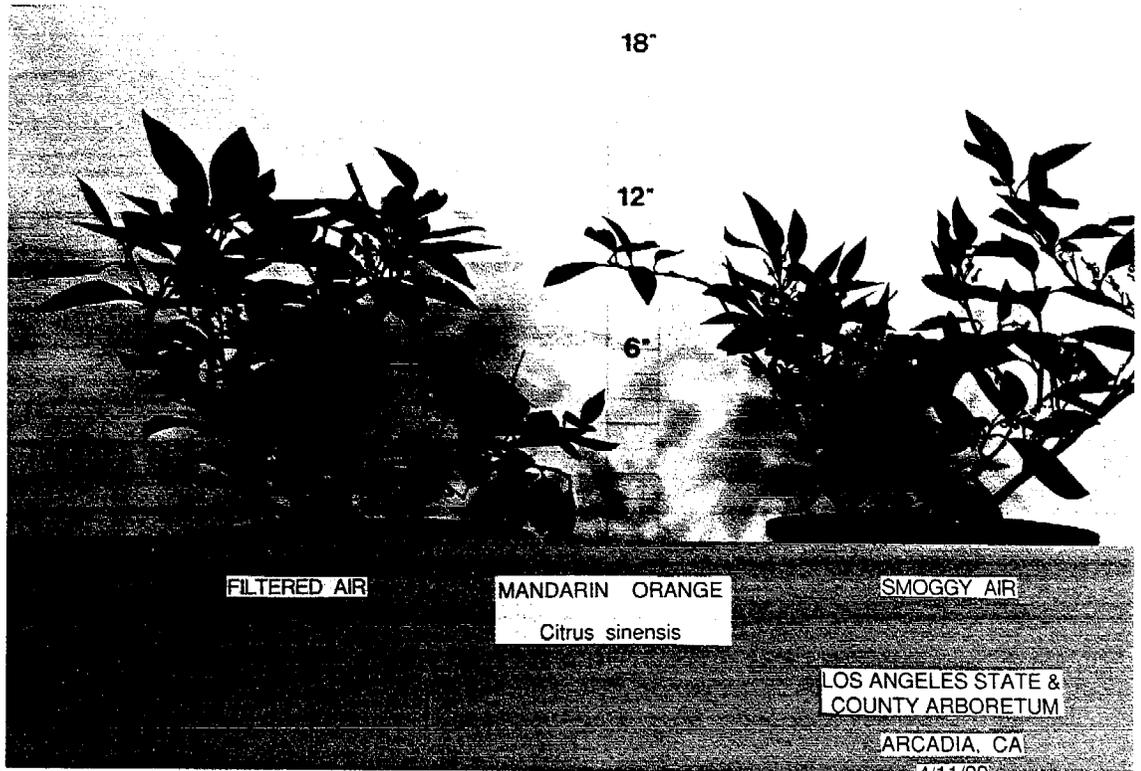
SERIES OF PHOTOGRAPHS
SHOWING HOW AIR POLLUTION

**REDUCES GROWTH:
CITRUS SINENSIS (Orange)**
4/11/90 to 10/24/90

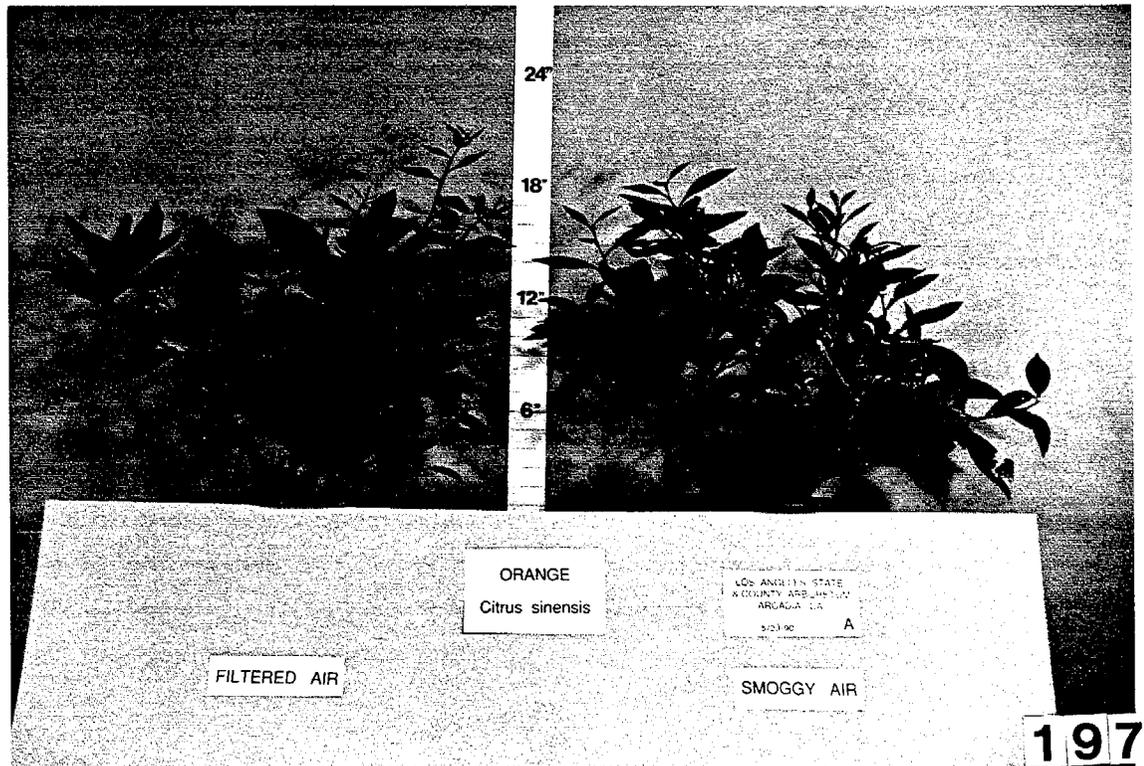
LOS ANGELES STATE AND COUNTY ARBORETUM, ARCADIA, 1990-91

GROWTH REDUCTION SERIES CITRUS SINENSIS (Orange)

4/11/90

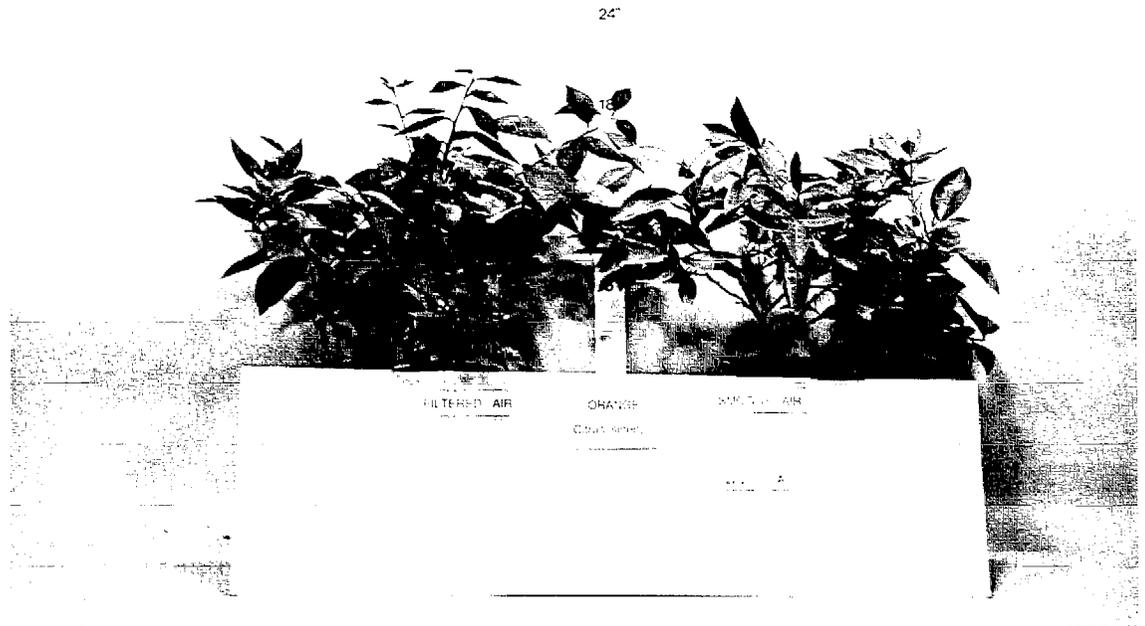


5/23/90



GROWTH REDUCTION SERIES CITRUS SINENSIS (Orange)

6/6/90

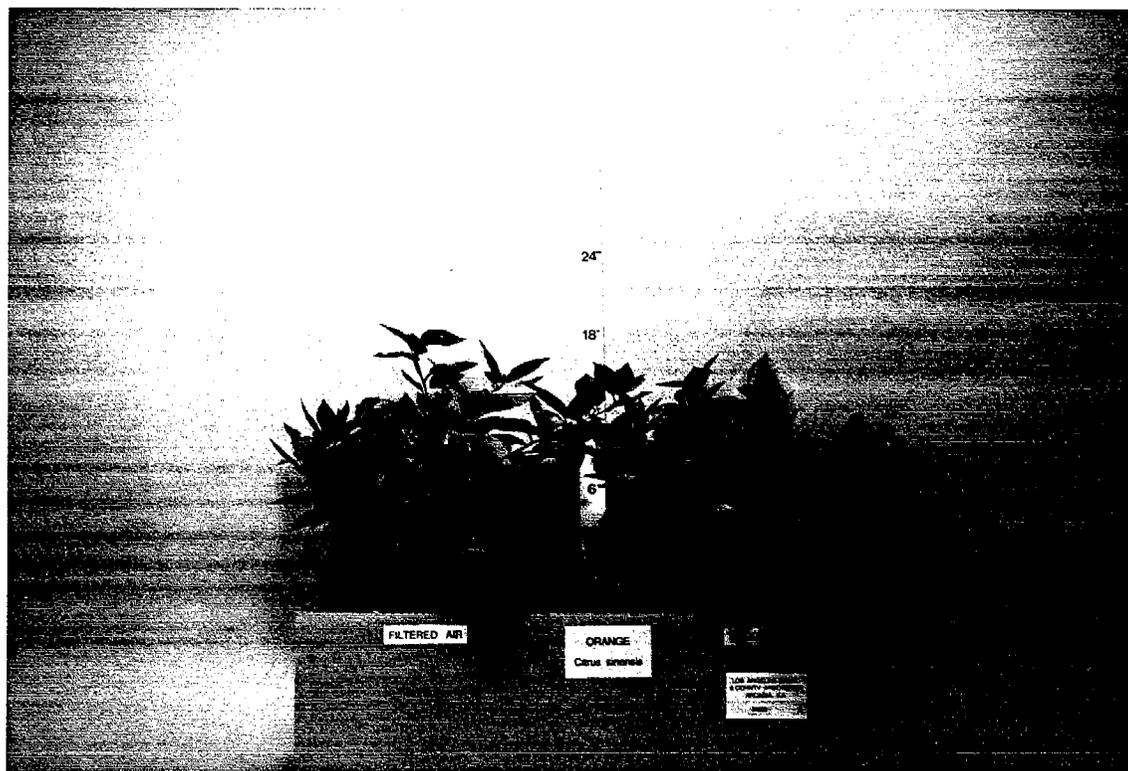


6/20/90



GROWTH REDUCTION SERIES CITRUS SINENSIS (Orange)

7/4/90

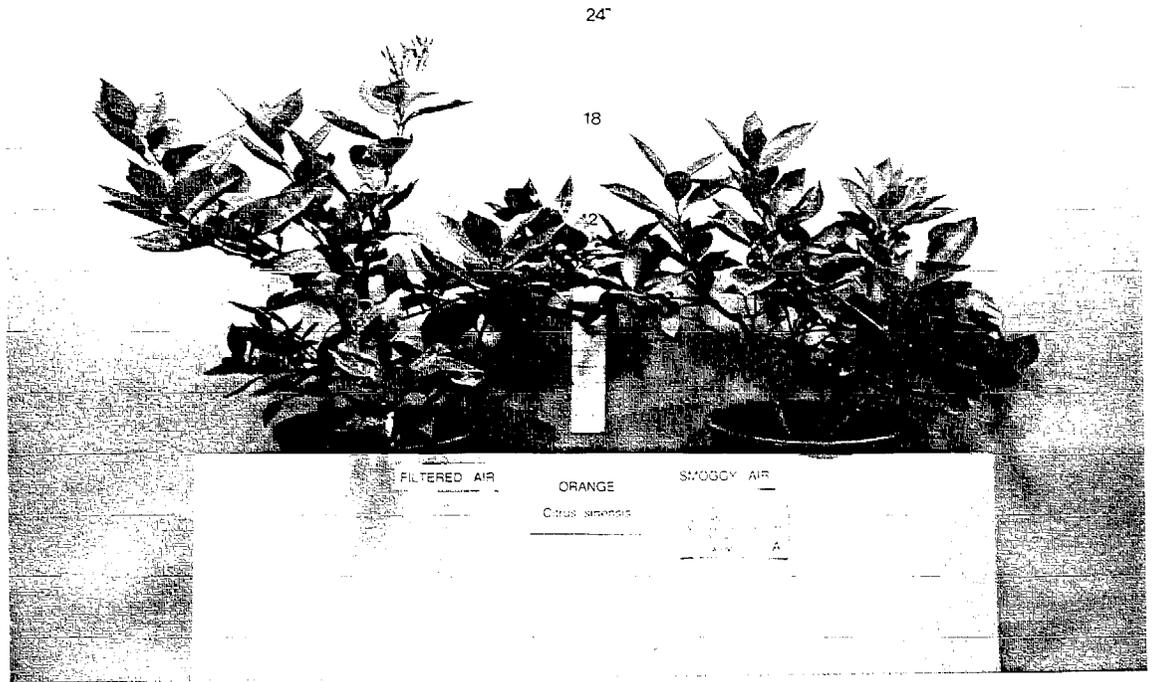


7/18/90

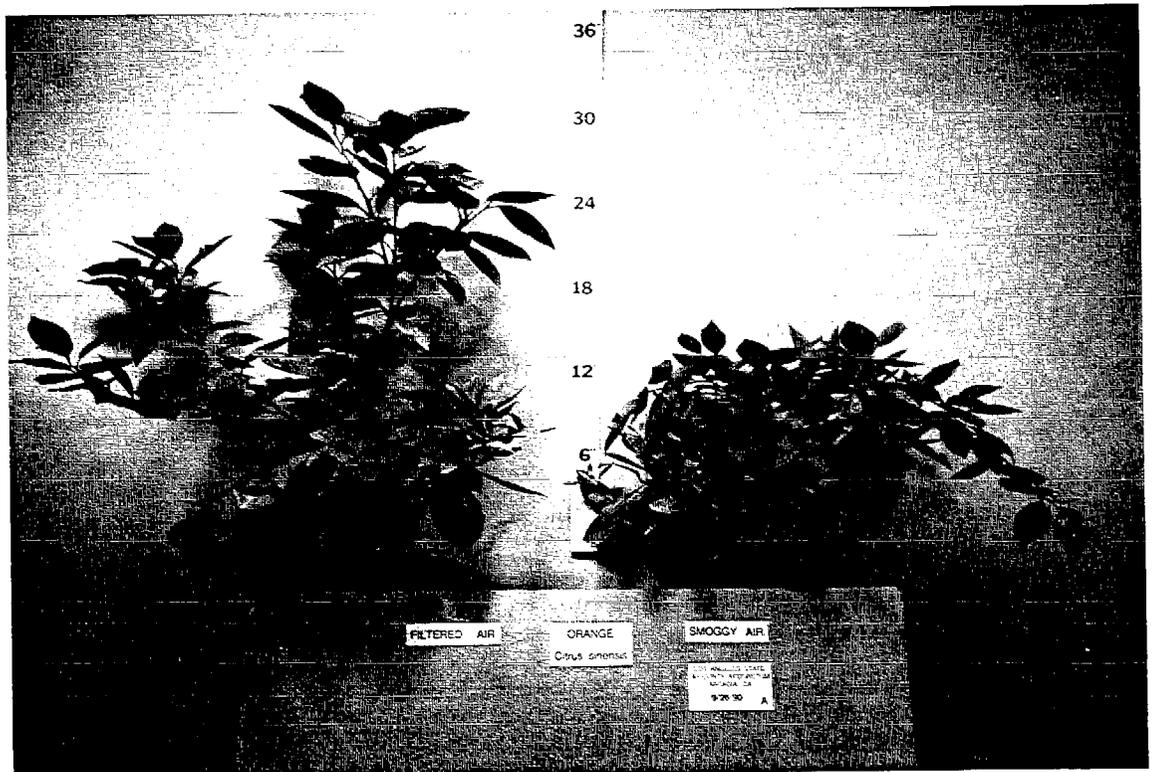


GROWTH REDUCTION SERIES CITRUS SINENSIS (Orange)

8/1/90



9/26/90



GROWTH REDUCTION SERIES CITRUS SINENSIS (Orange)

10/10/90



10/24/90



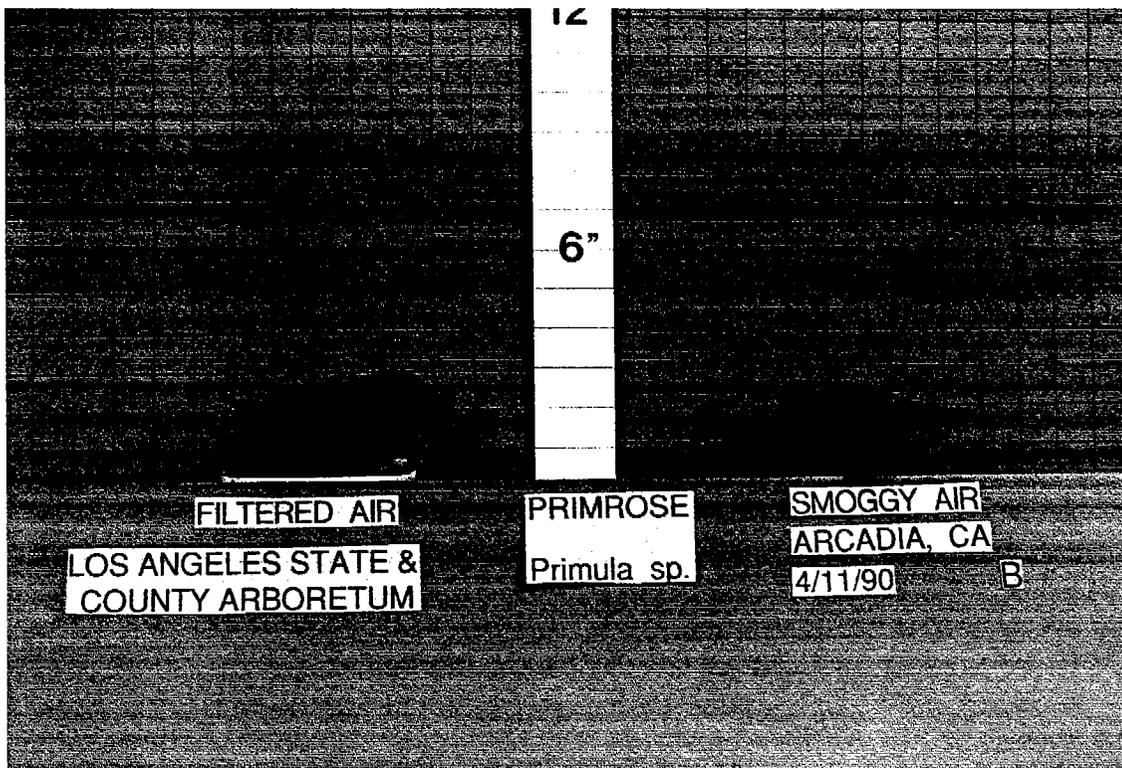
SERIES OF PHOTOGRAPHS
SHOWING HOW AIR POLLUTION

REDUCES GROWTH:
PRIMULA SP. (Primrose)
4/11/90 to 8/15/90

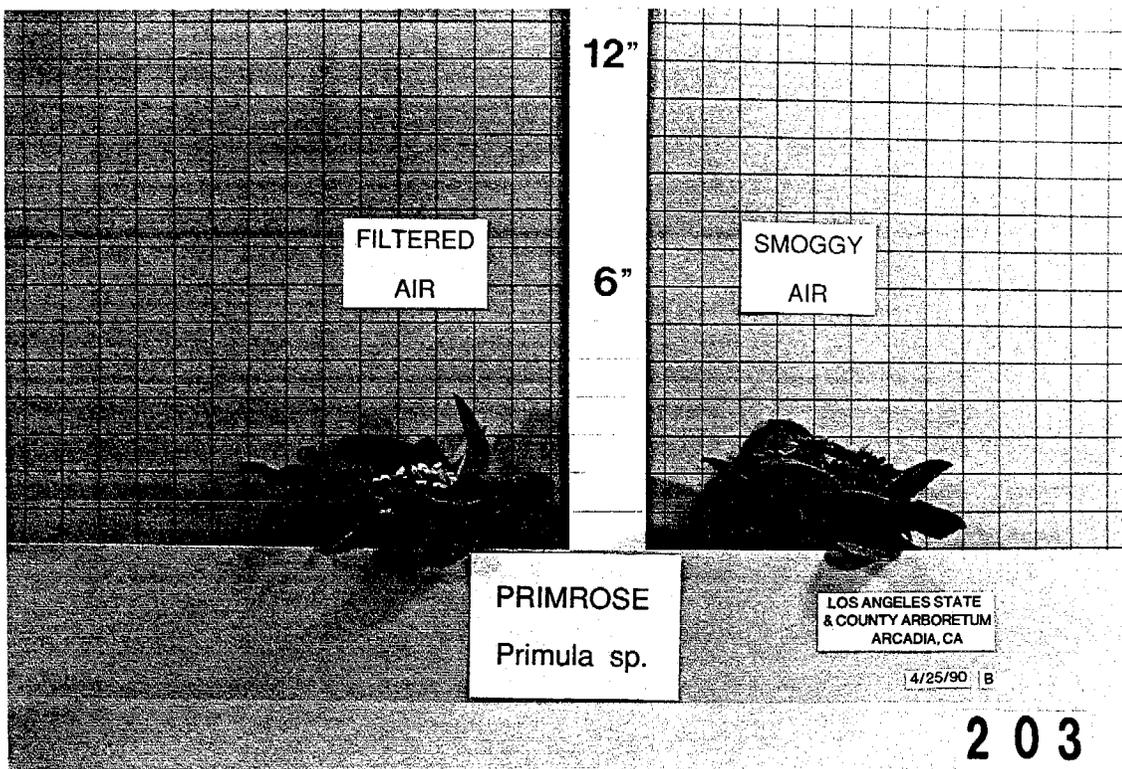
LOS ANGELES STATE AND COUNTY ARBORETUM, ARCADIA, 1990-91

GROWTH REDUCTION SERIES PRIMULA SP. (Primrose)

4/11/90

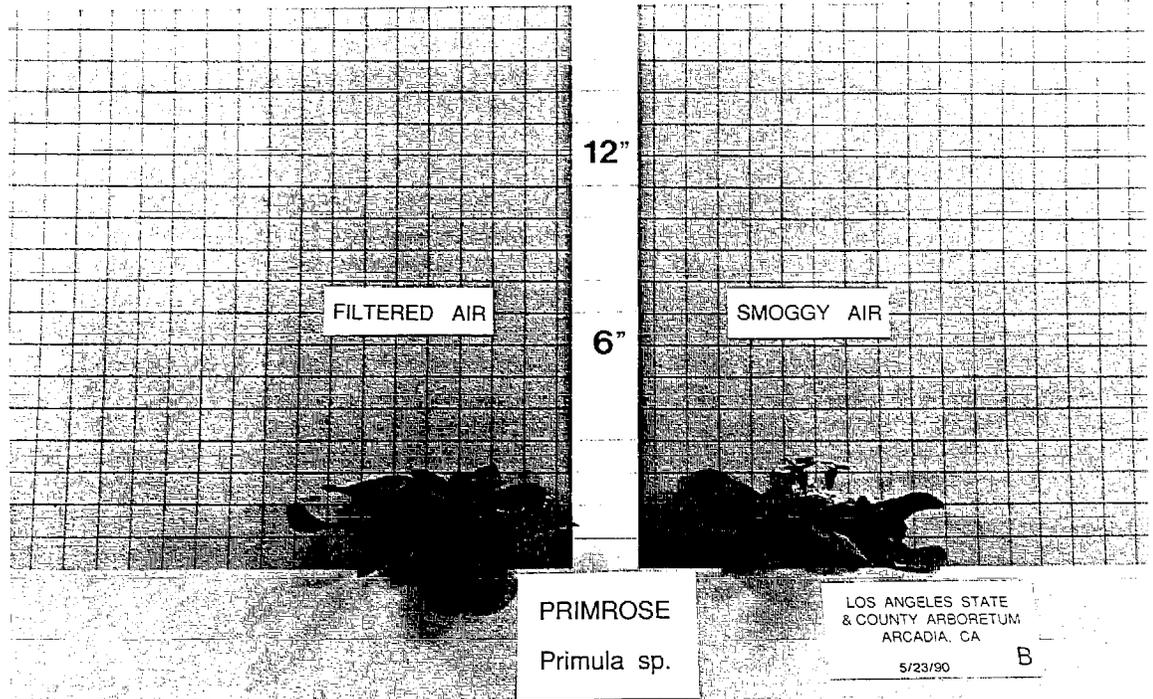


4/25/90

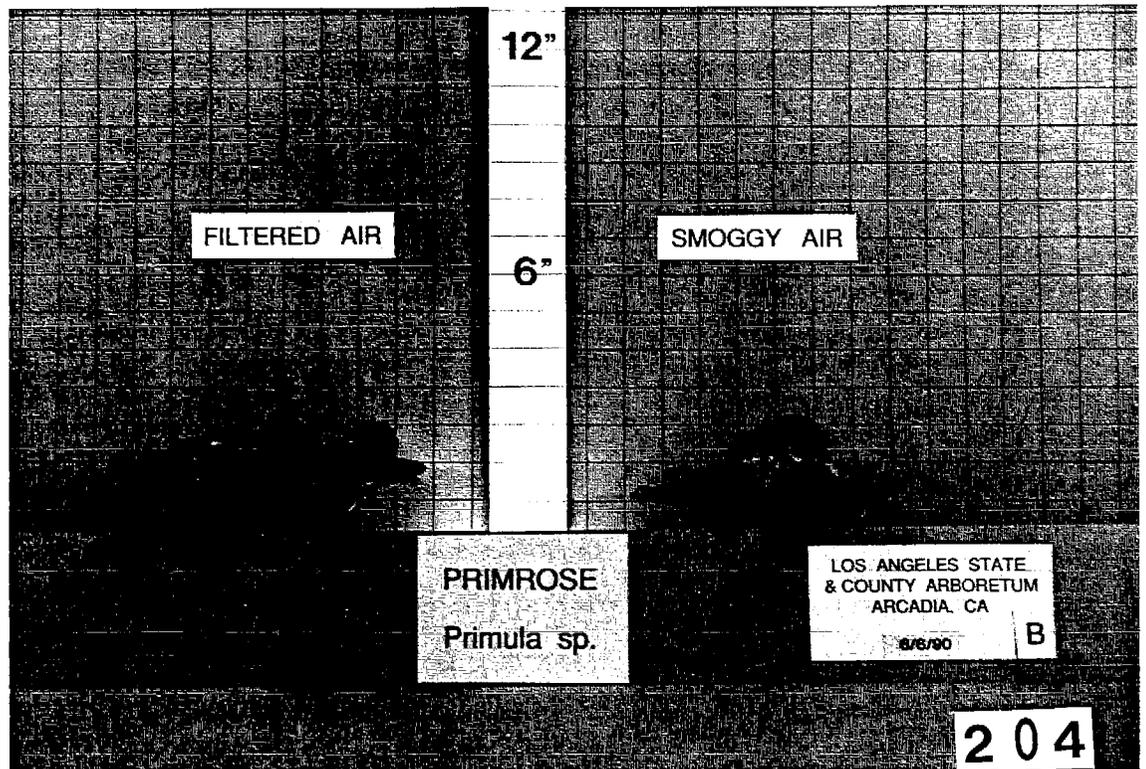


GROWTH REDUCTION SERIES PRIMULA SP. (Primrose)

5/23/90

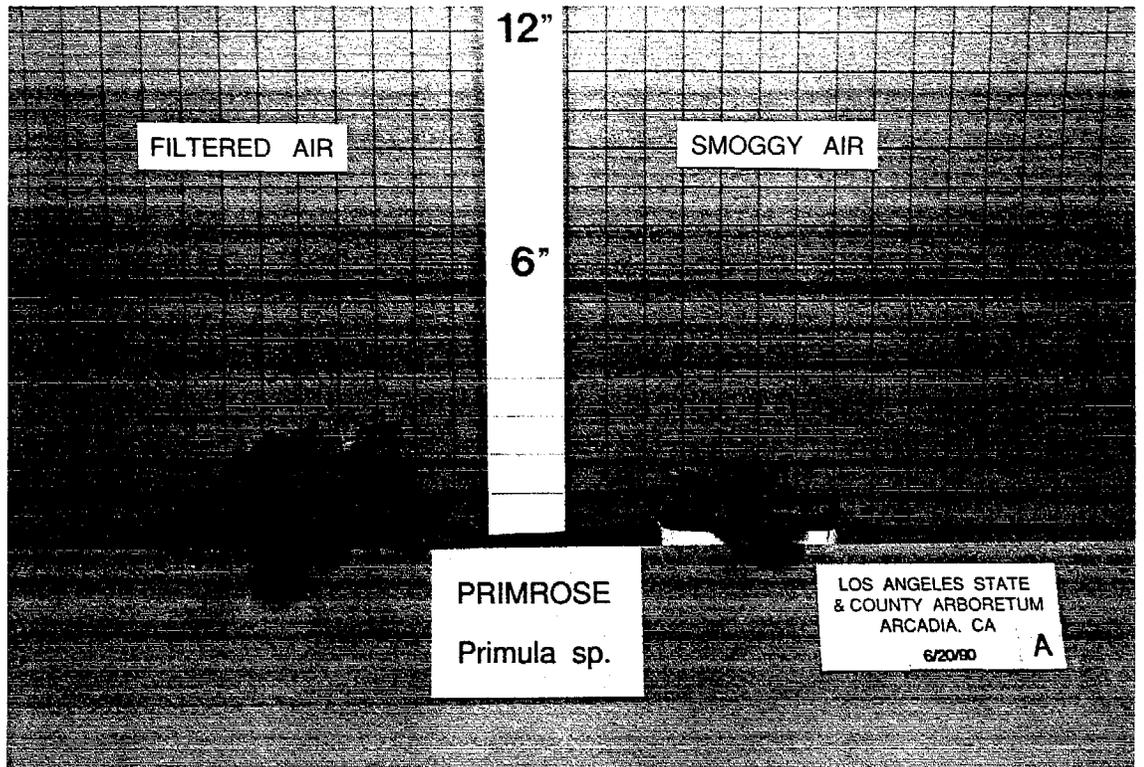


6/6/90

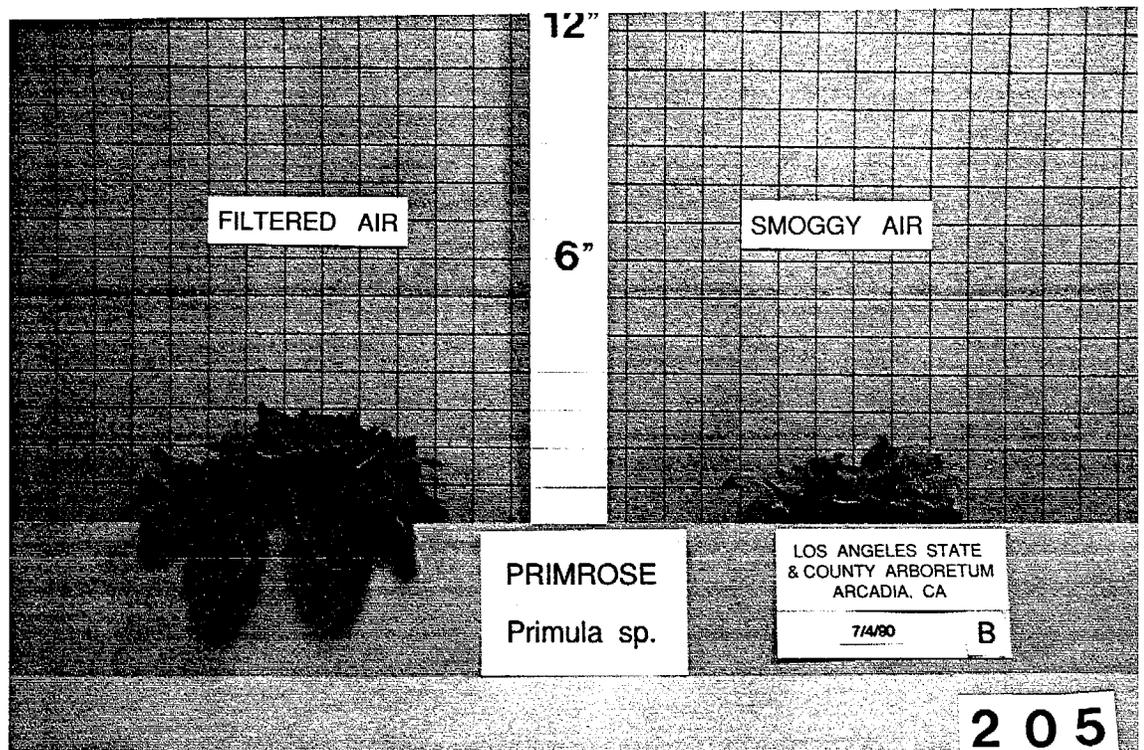


GROWTH REDUCTION SERIES PRIMULA SP. (Primrose)

6/20/90

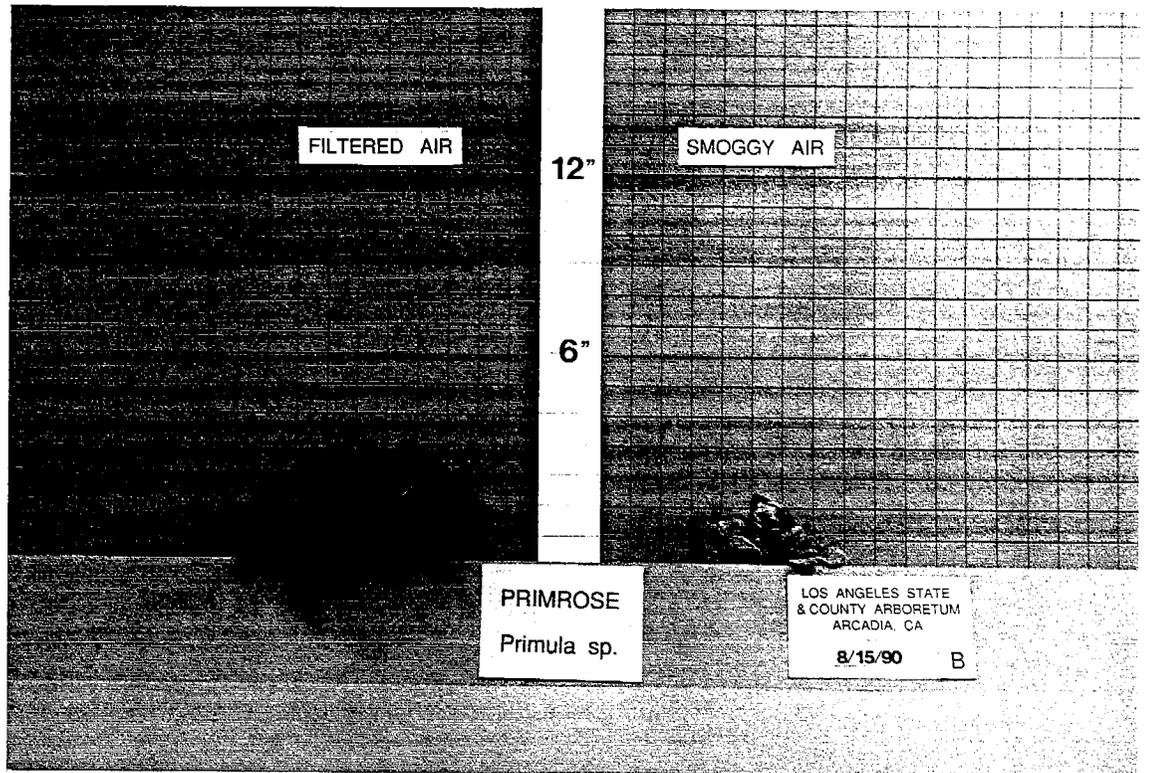


7/4/90



GROWTH REDUCTION SERIES PRIMULA SP. (Primrose)

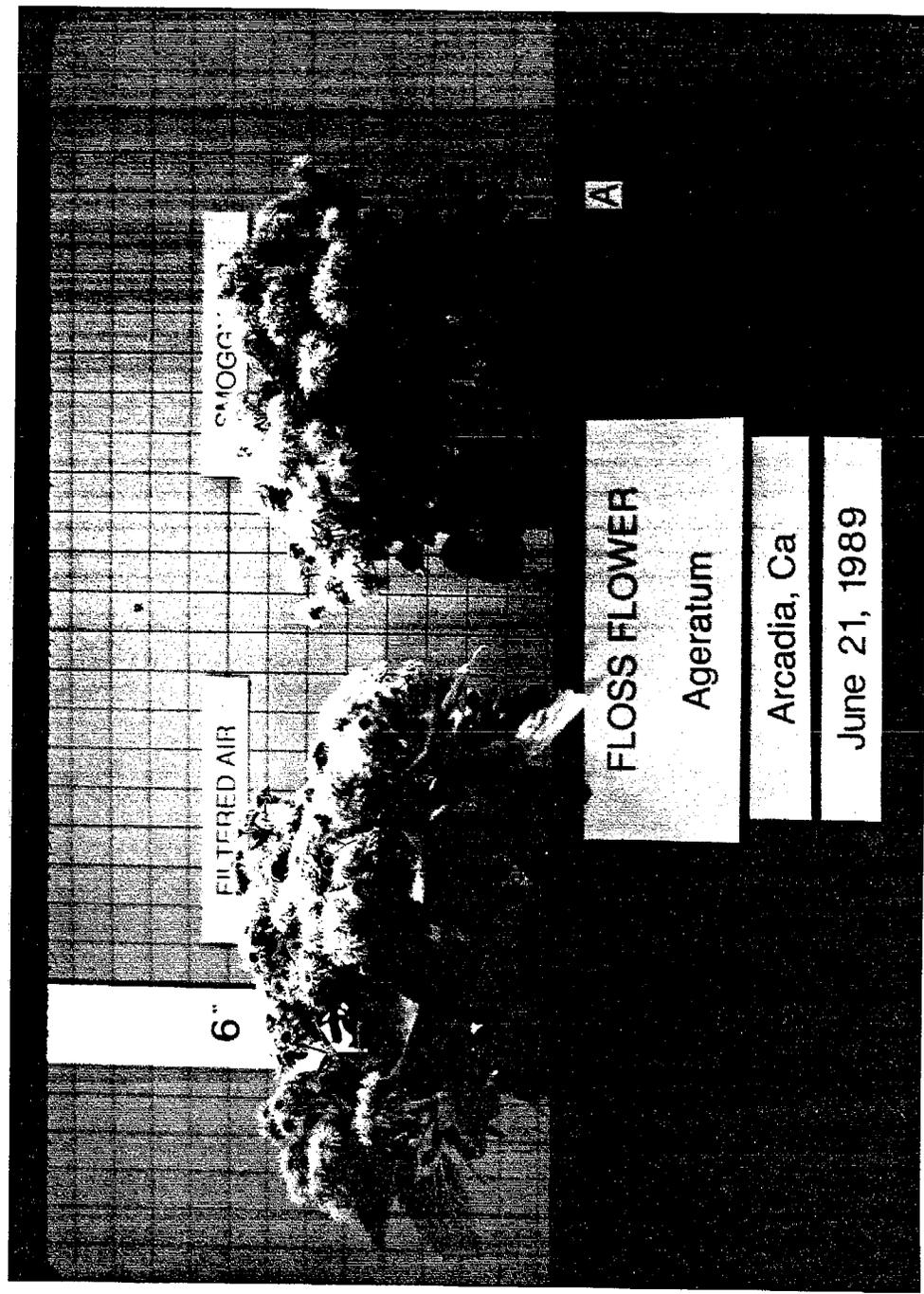
8/15/90



**AIR POLLUTION GREENHOUSE
EXAMPLES OF SIGNS USED
TO IDENTIFY SYMPTOMS, 1989**

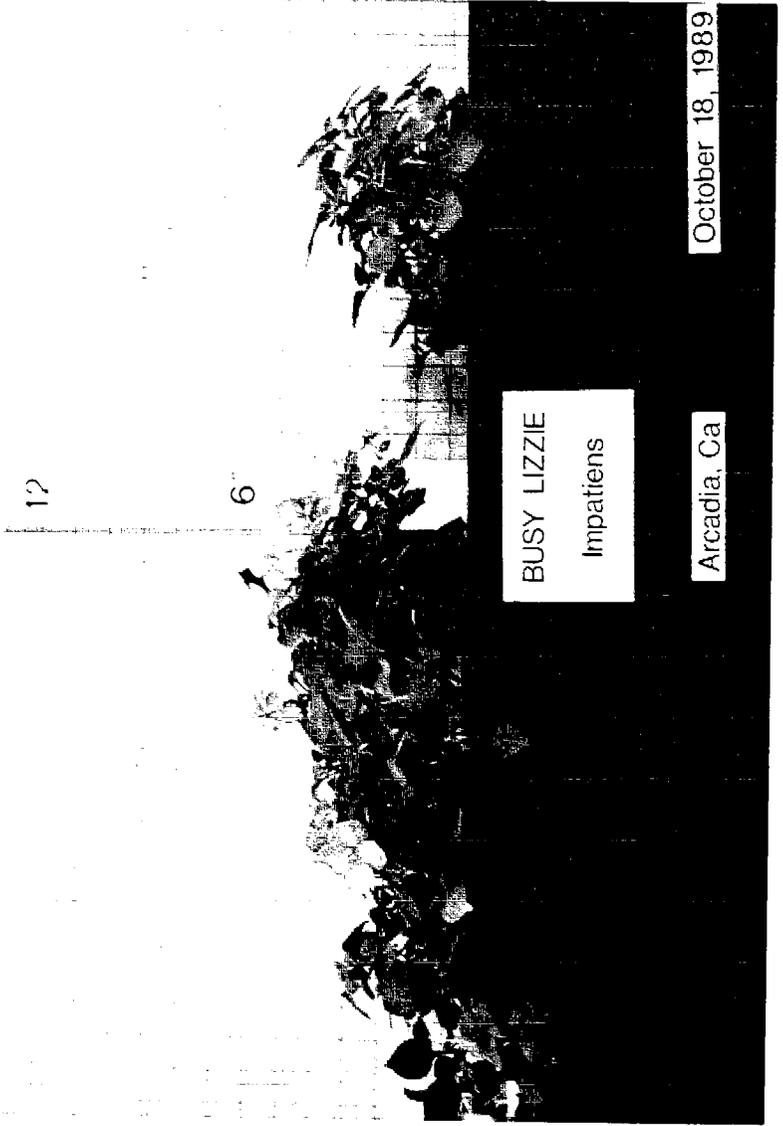
LOS ANGELES STATE AND COUNTY ARBORETUM, ARCADIA CA

REDUCED SIZE



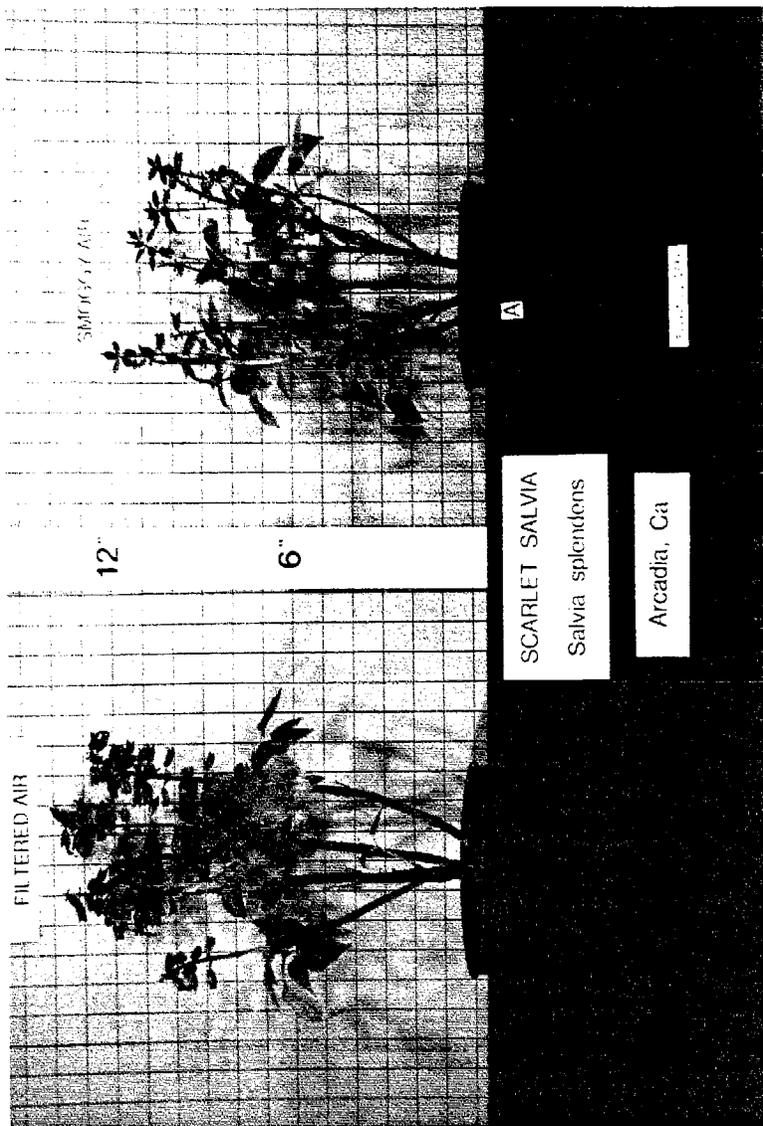
REDUCED GROWTH

BUSY LIZZIE *Impatiens* sp.

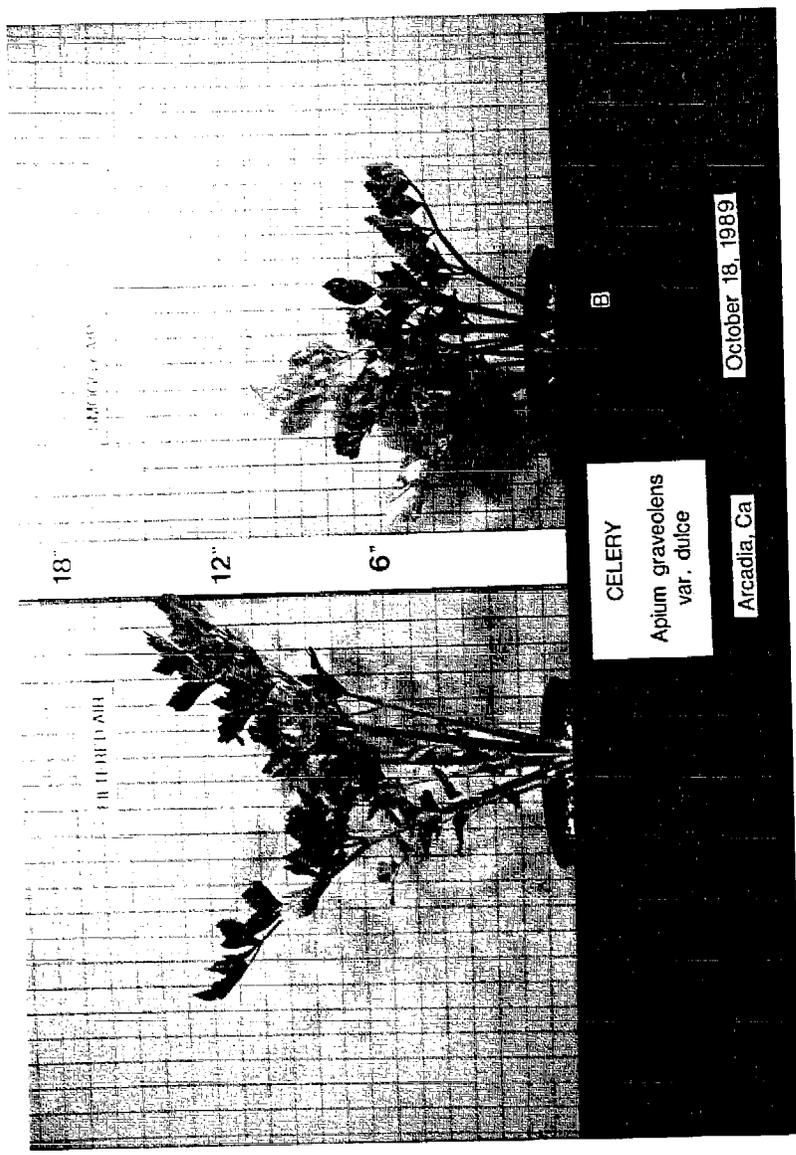


SCARLET SAGE

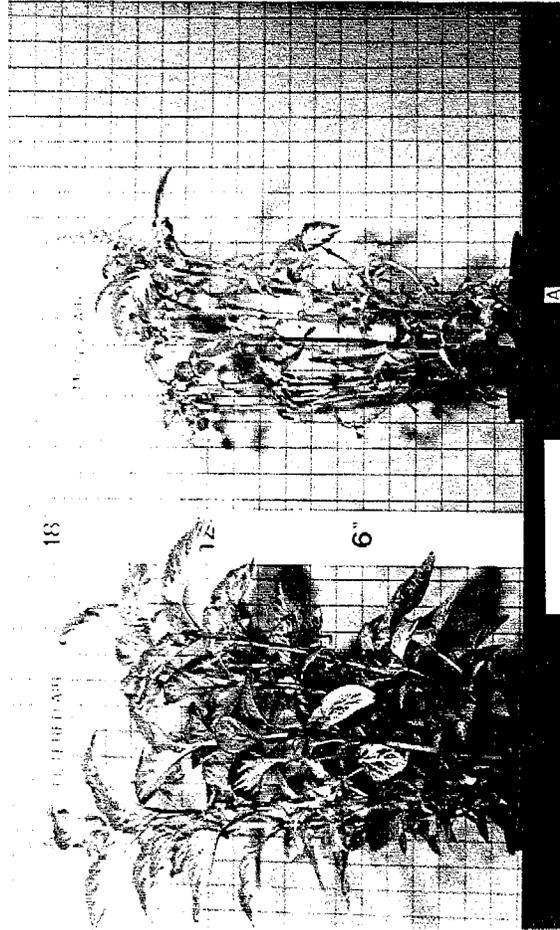
Salvia splendens



REDUCED SIZE



LEGGY STEMS



COLEUS
Coleus hybridus

August 16, 1989

Arcadia, Ca

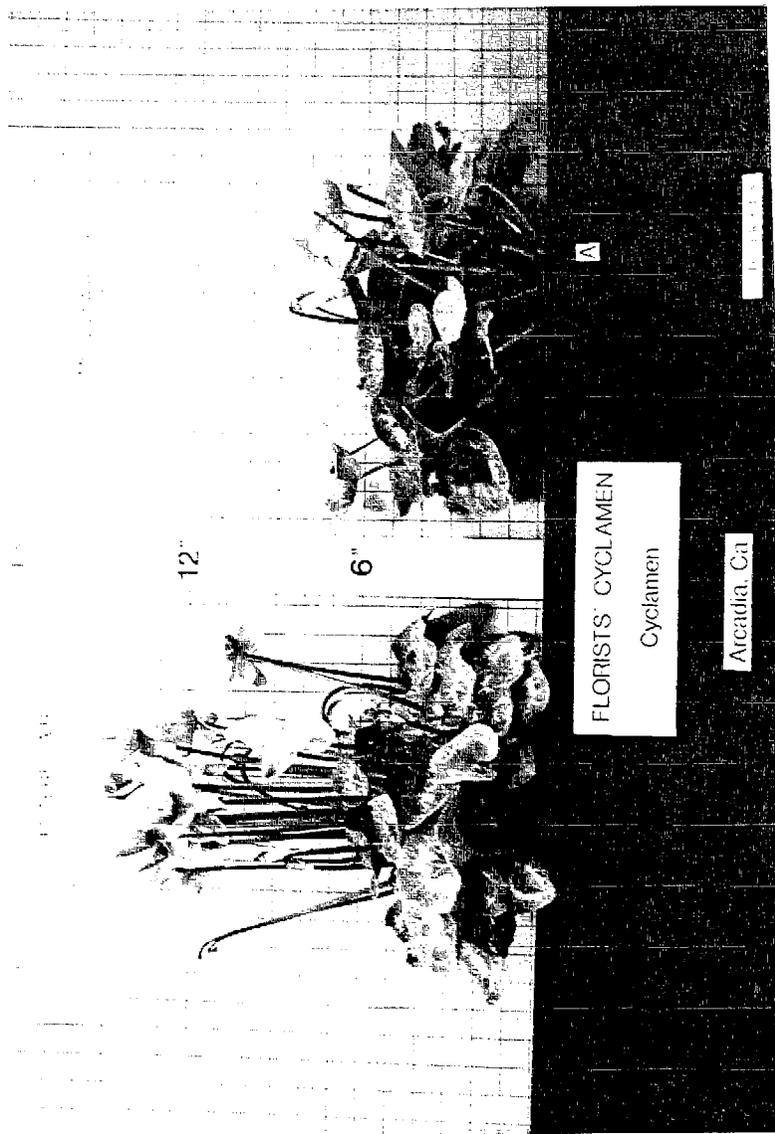
2 | 3

COLEUS

Coleus hybridus

FLORISTS' CYCLAMEN

Cyclamen sp.



FLORISTS' CYCLAMEN
Cyclamen

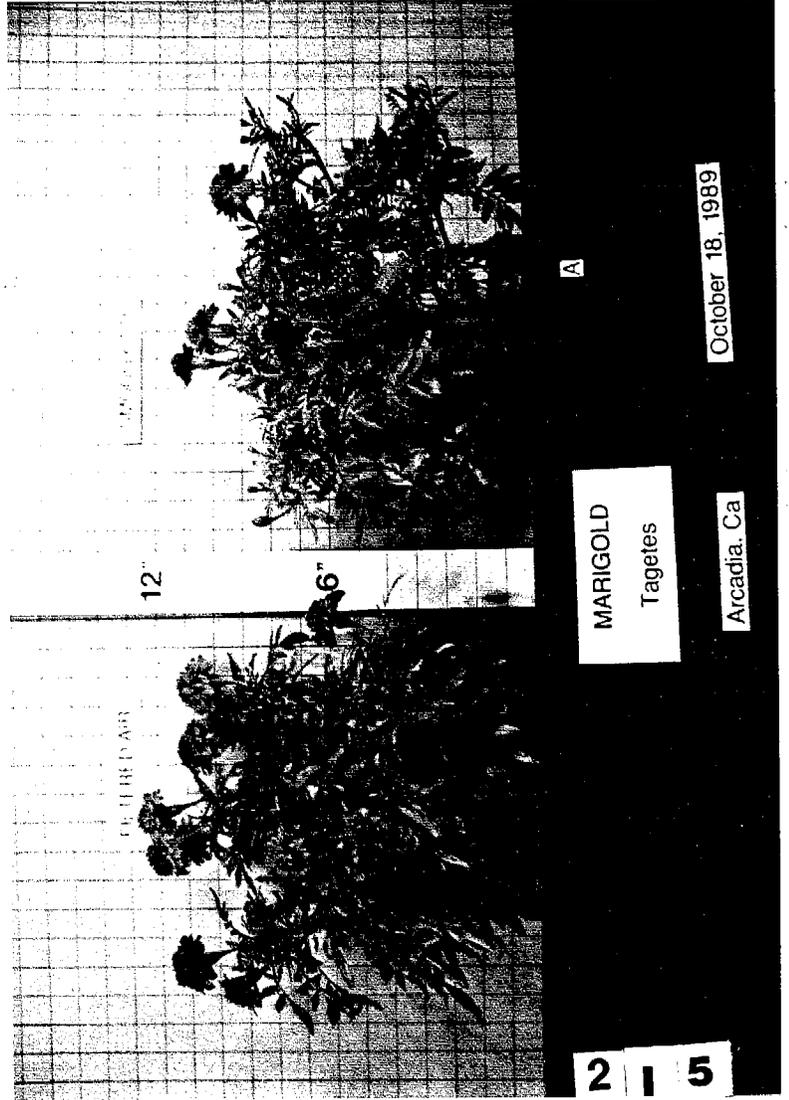
Arcadia, Ca

1-1-1-1

YELLOW LEAVES

MARIGOLD

Tagetes sp.



YELLOW LEAVES

PEPPER *Capsicum annuum*

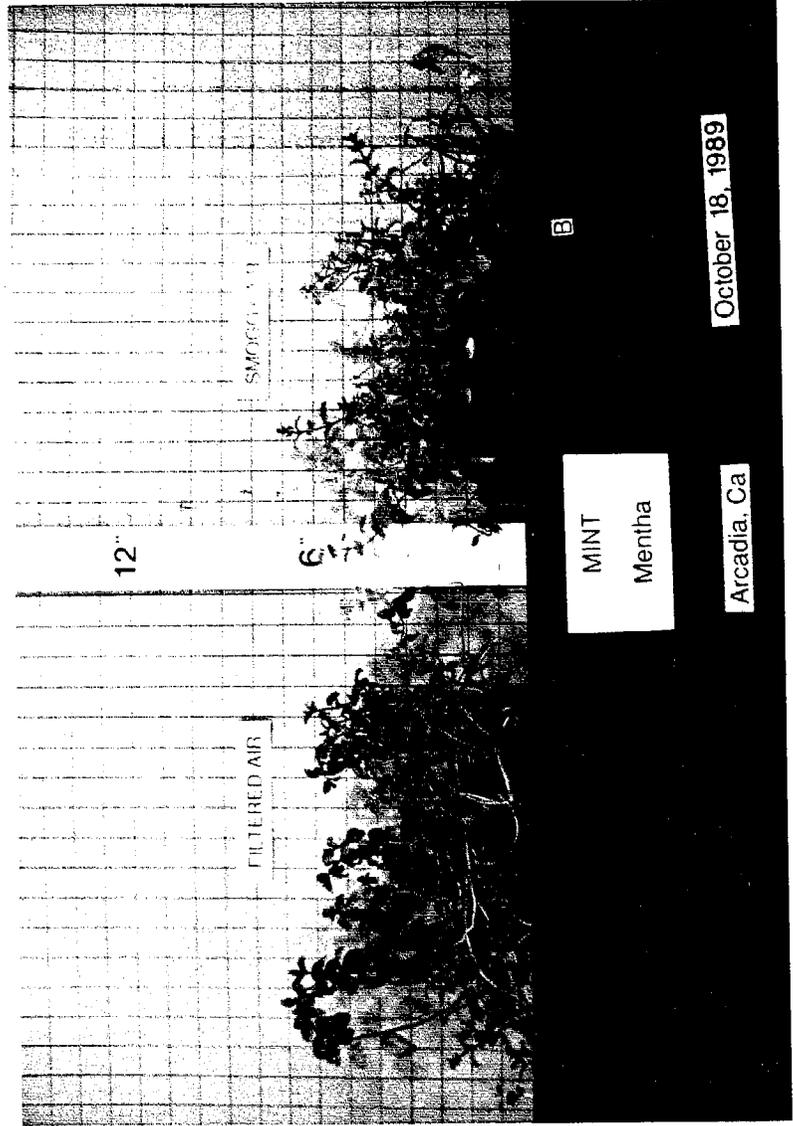


Pepper
Capsicum annuum

Arcadia, Ca

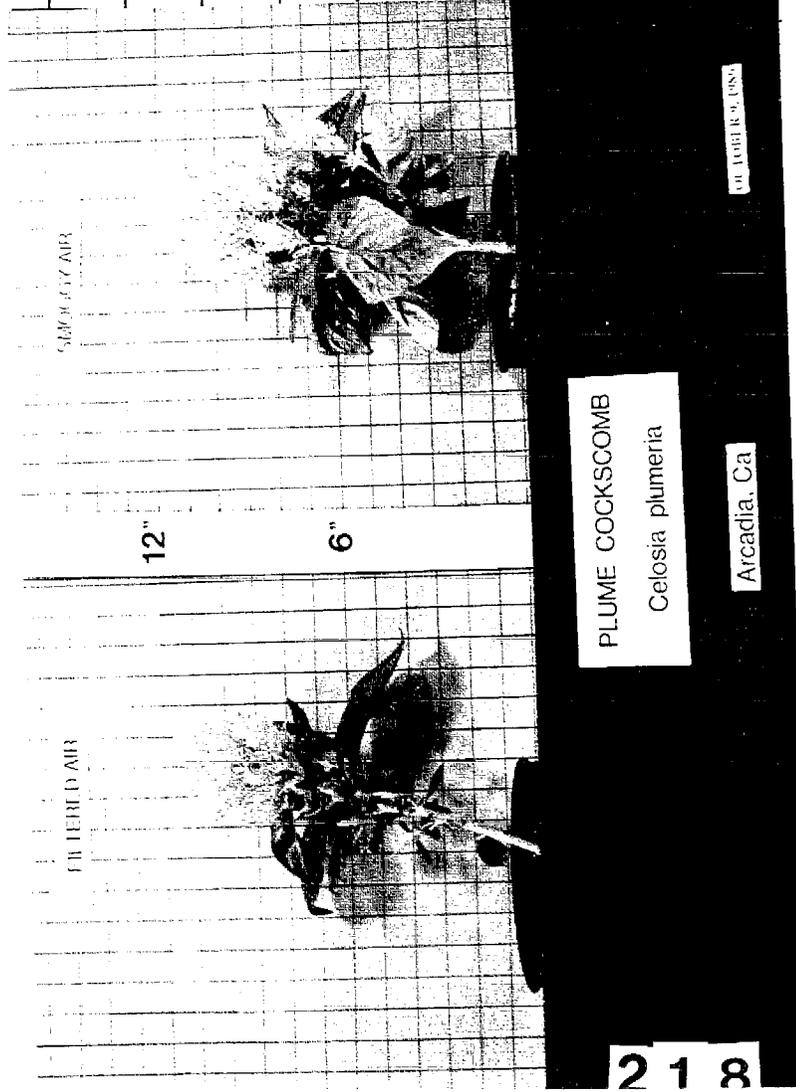
October 18, 1989

FADDES COLOR



COLOR CHANGE

FLOWERS AND DIES SOONER



FILTERED AIR

12"

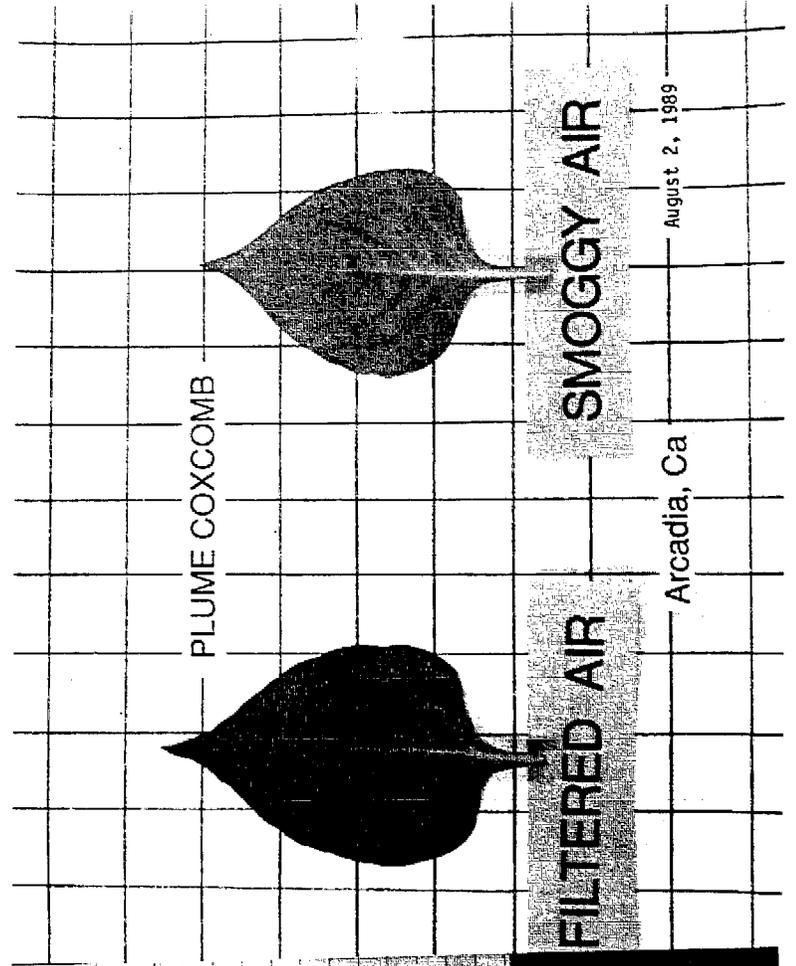
SMOGGY AIR

6"

PLUME COCKSCOMB
Celosia plumeria

Arcadia, Ca

DU TOBIER 9, USA



PLUME COXCOMB

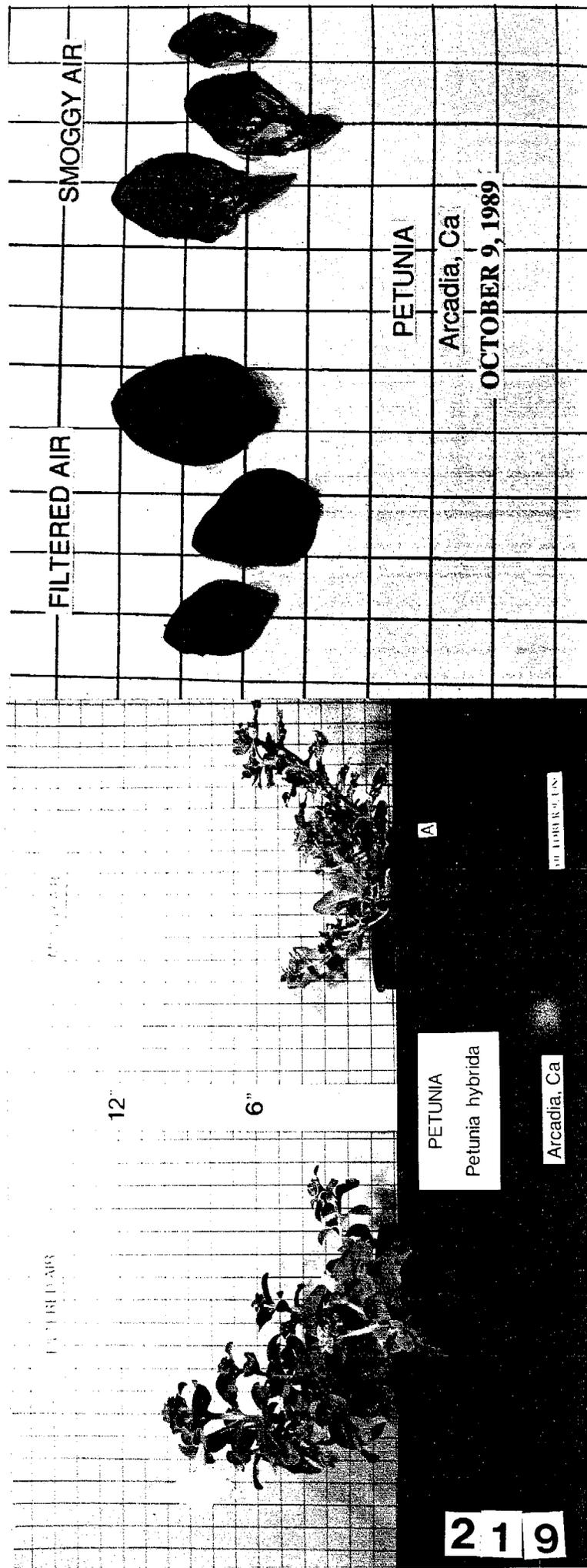
FILTERED AIR

SMOGGY AIR

Arcadia, Ca

August 2, 1989

REDUCED SIZE LEAF SPOTS

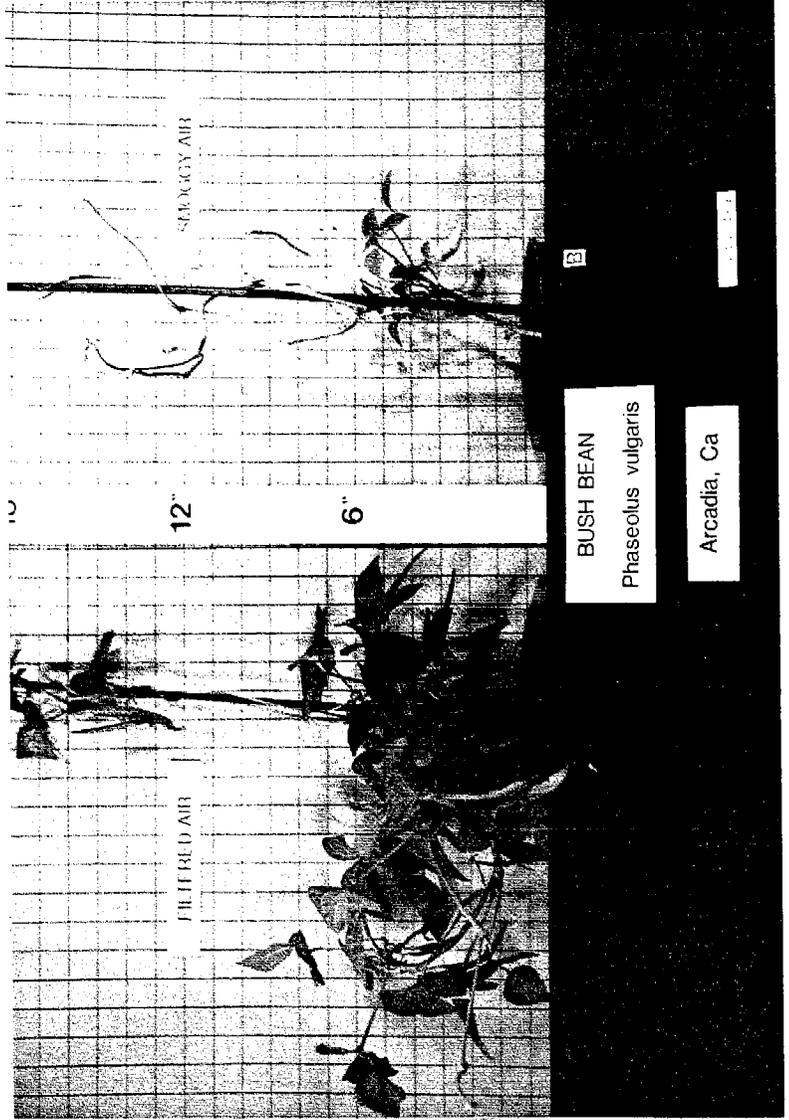


LEAF SPOTS



LEAF SPOTS

KENTUCKY BLUE BEAN *Phaseolus vulgaris*



LEAF SPOTS



**AIR POLLUTION GREENHOUSE
RESPONSE TO THE
QUESTIONNAIRE**

LOS ANGELES STATE AND COUNTY ARBORETUM, ARCADIA 1990-91

THE AIR POLLUTION GREENHOUSE VISITOR SURVEY, 1989-1990

Visitors were asked to complete a brief survey so their responses to the display could be evaluated.

The following charts list the questions asked, and describe how the questions were answered by the visitors in 1989-1990.

Visitor responses are important factors in the design of improvements to the display. 12% of the visitors responded to the survey.

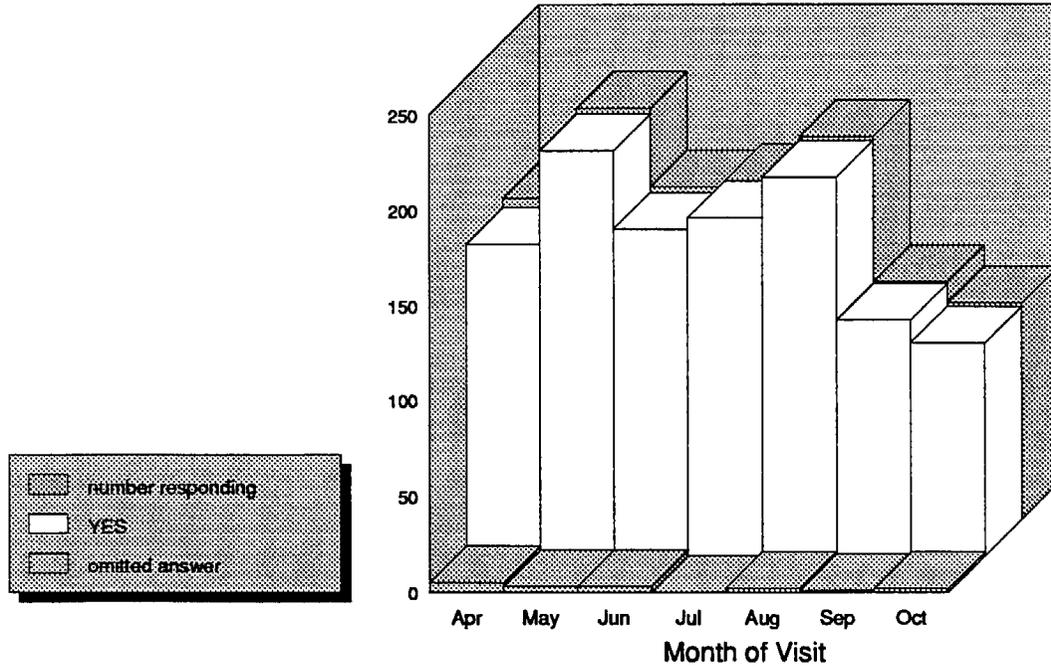
L.A. STATE AND COUNTY ARBORETUM, ARCADIA CA

SURVEY QUESTIONS, 1989-1990 AIR POLLUTION GREENHOUSE EXHIBIT

Date _____
Did you find the exhibit informative? Yes/No _____
Easy to understand? Yes/No _____
Which part of the exhibit did you find most interesting? (rate 1 thru 3, 1 being the highest)
Signs and other graphics _____
Monitoring equipment _____
Plants _____
Prior to seeing the exhibit, did you know that air pollution could injure plants? Yes/No _____
Have you noticed the effects of air pollution on plants near your home? Yes/No _____
Which plants and symptoms? _____
What did you do today to reduce air pollution? _____
Do you think your individual actions can help improve air quality? Yes/No _____
List plants in the exhibit that are of special interest to you. _____
List plants you would like to see added to the exhibit. _____
Additional comments: _____

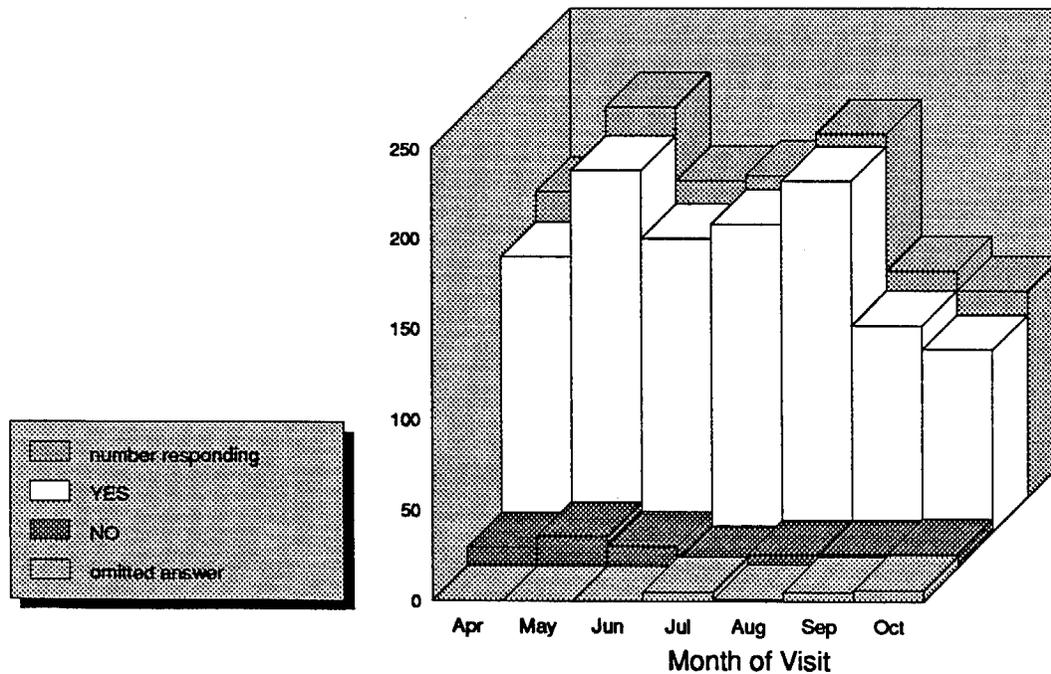
L.A. STATE AND COUNTY ARBORETUM, ARCADIA CA

Analysis of Questionnaire, 1989-1990
WAS THE EXHIBIT INFORMATIVE?



L.A. STATE AND COUNTY ARBORETUM, ARCADIA

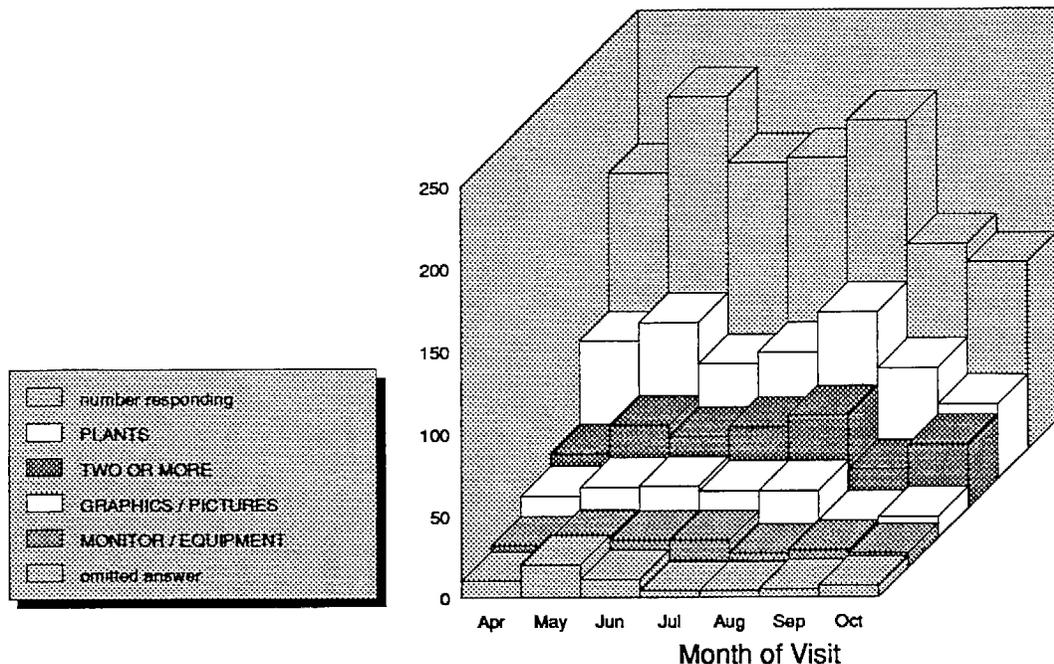
Analysis of Questionnaire, 1989-1990
WAS THE EXHIBIT EASY TO UNDERSTAND?



L.A. STATE AND COUNTY ARBORETUM, ARCADIA

Analysis of Questionnaire, 1989-1990

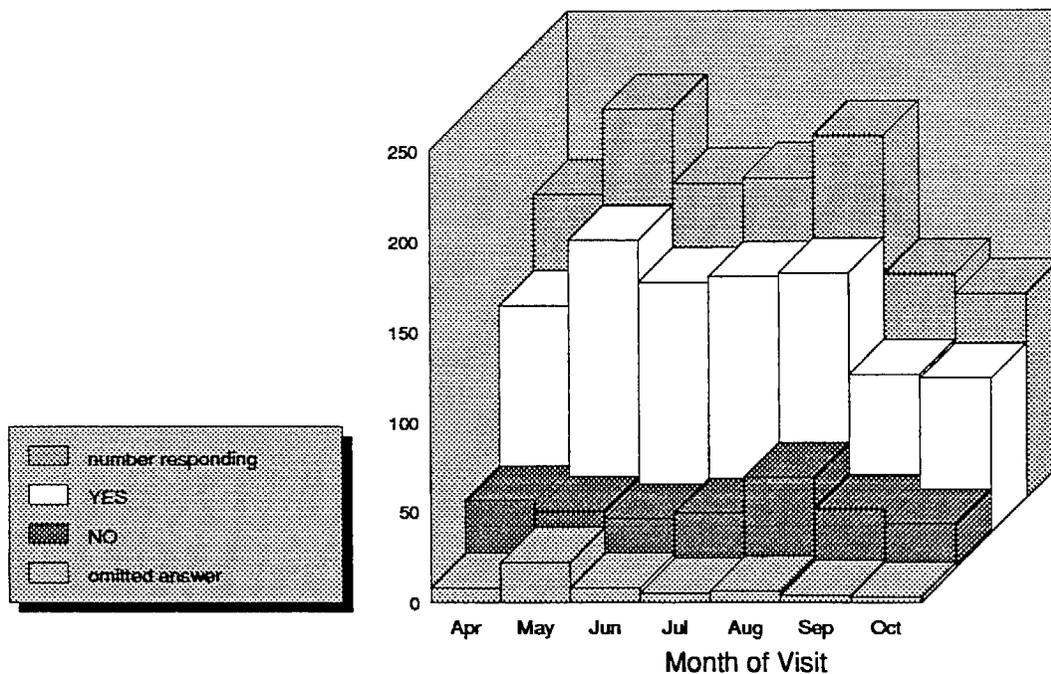
WHAT PART DID YOU FIND MOST INTERESTING?



L.A. CITY AND COUNTY ARBORETUM, ARCADIA

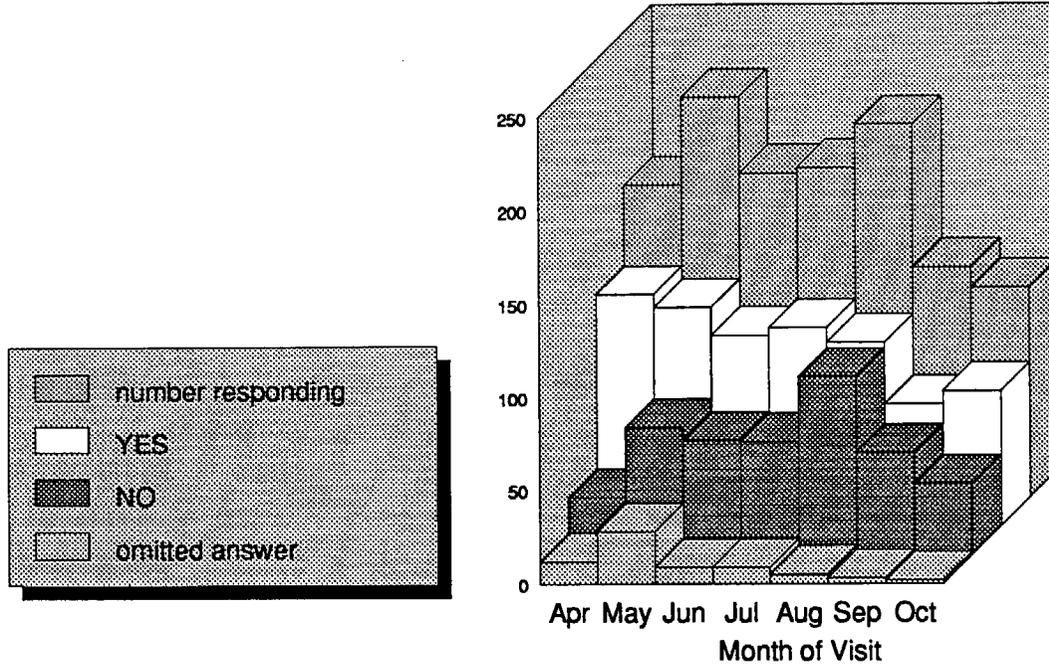
Analysis of Questionnaire, 1989-1990

ALREADY KNEW POLLUTION DAMAGES PLANTS



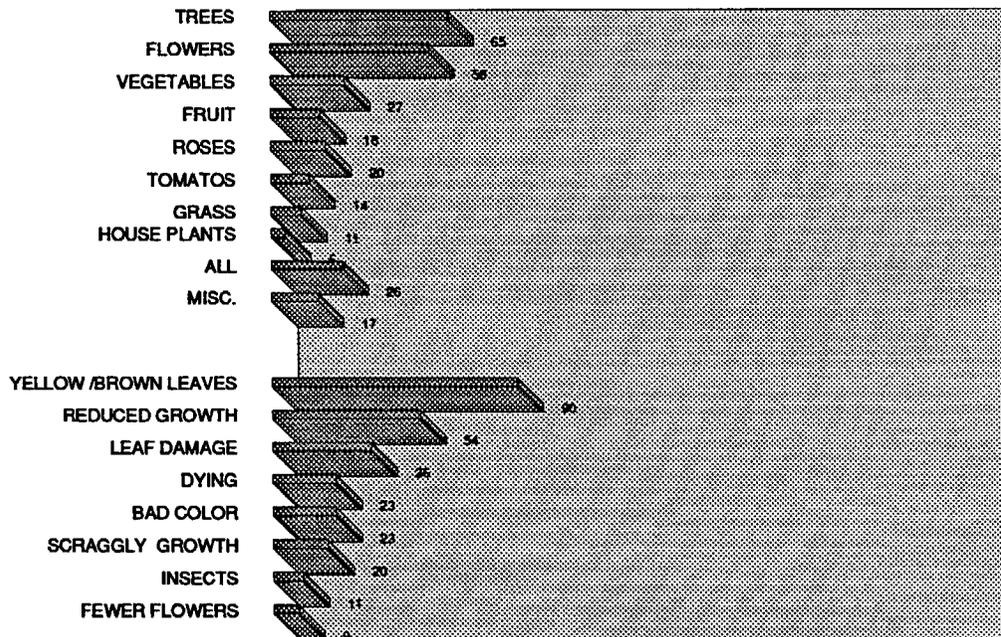
L.A. STATE AND COUNTY ARBORETUM, ARCADIA

NOTICED EFFECTS ON PLANTS NEAR MY HOME



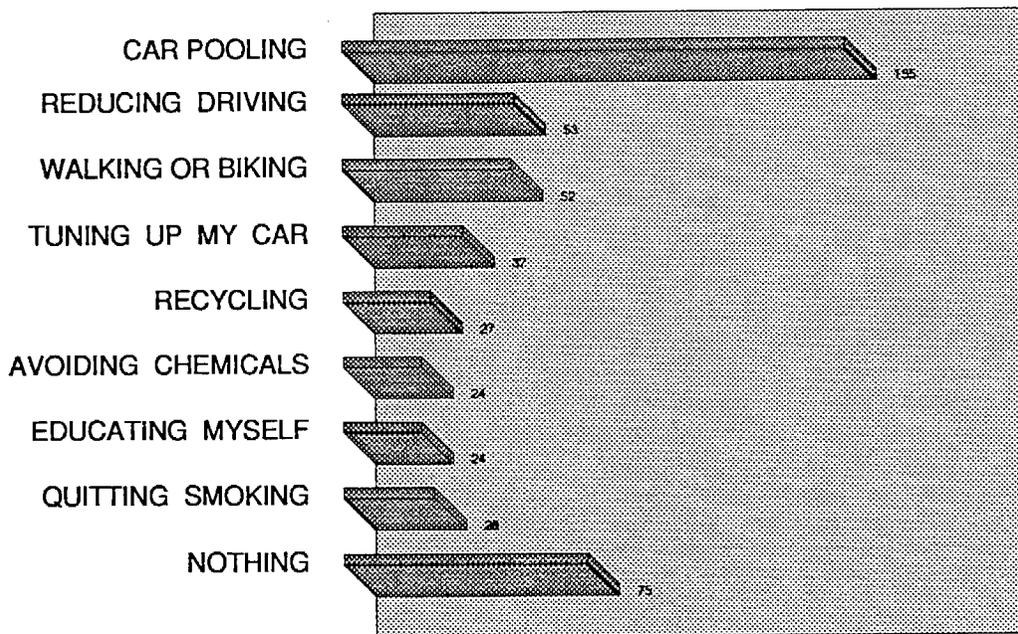
L.A. CITY AND COUNTY ARBORETUM, ARCADIA

POLLUTION DAMAGE VISITORS SEE NEAR HOMES NAME OF PLANT AND TYPE OF DAMAGE SEEN



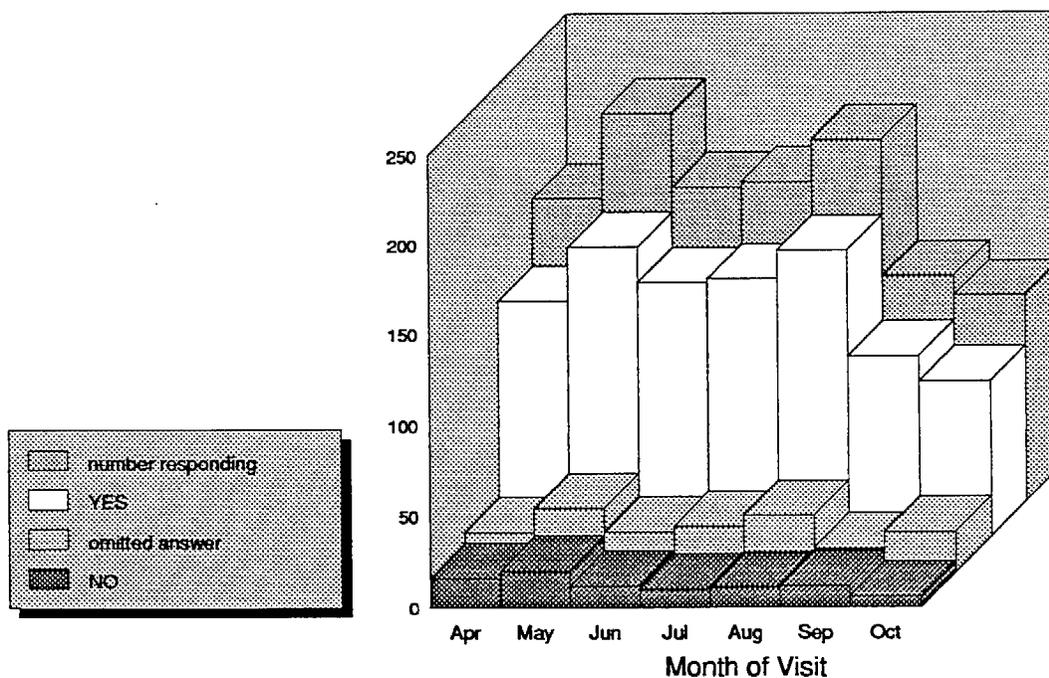
AIR POLLUTION GREENHOUSE, LASCA 1989-90

Analysis of Questionnaire, 1990 HOW I REDUCED AIR POLLUTION TODAY



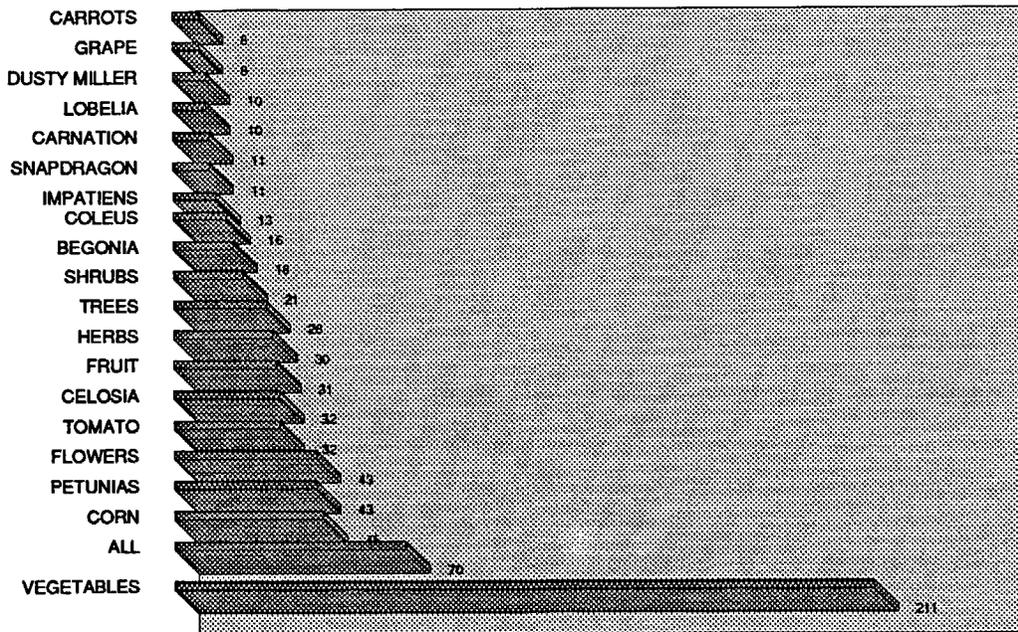
L.A. STATE AND COUNTY ARBORETUM, ARCADIA

Analysis of Questionnaire, 1989-1990 MY ACTIONS CAN HELP IMPROVE AIR QUALITY



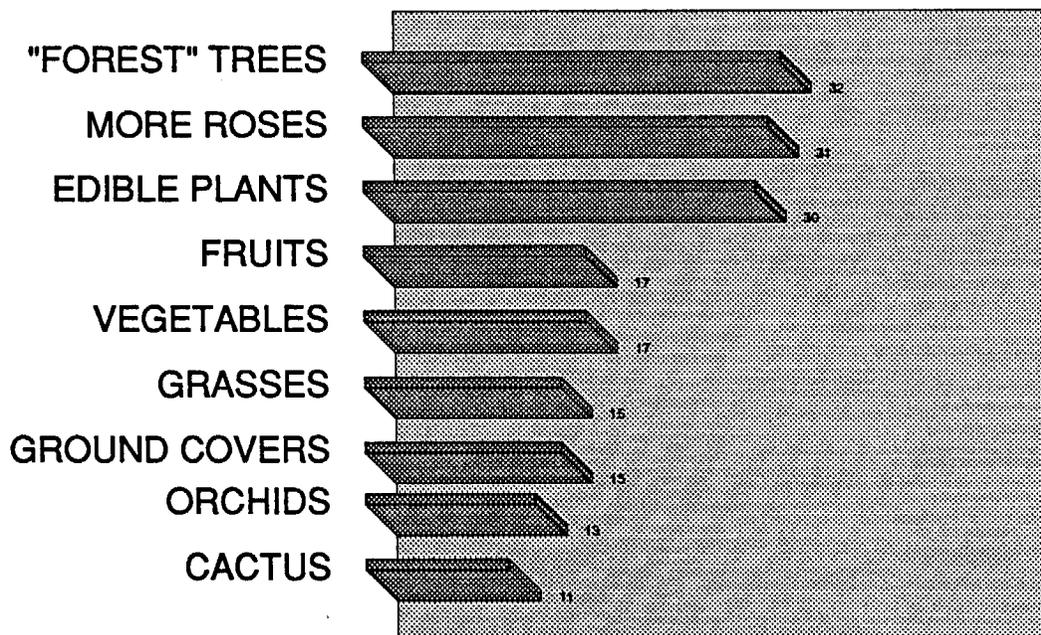
L.A. STATE AND COUNTY ARBORETUM, ARCADIA

Analysis of Questionnaire, 1989-1990
PLANTS OF SPECIAL INTEREST TO ME



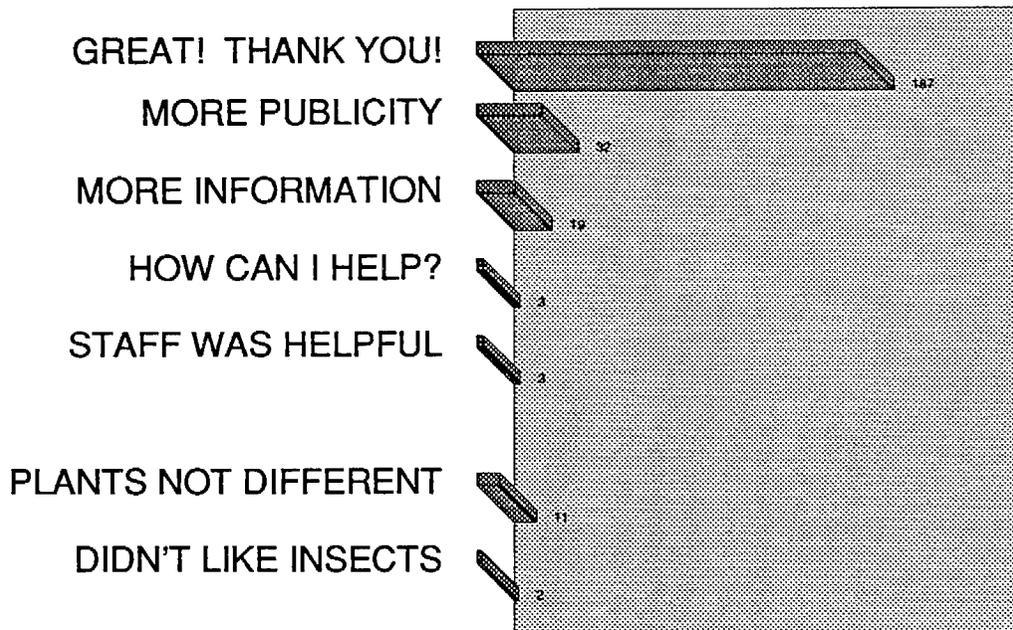
L.A. STATE AND COUNTY ARBORETUM, ARCADIA

Analysis of Questionnaire, 1989-1990
PLANTS I WANT ADDED TO THE DISPLAY



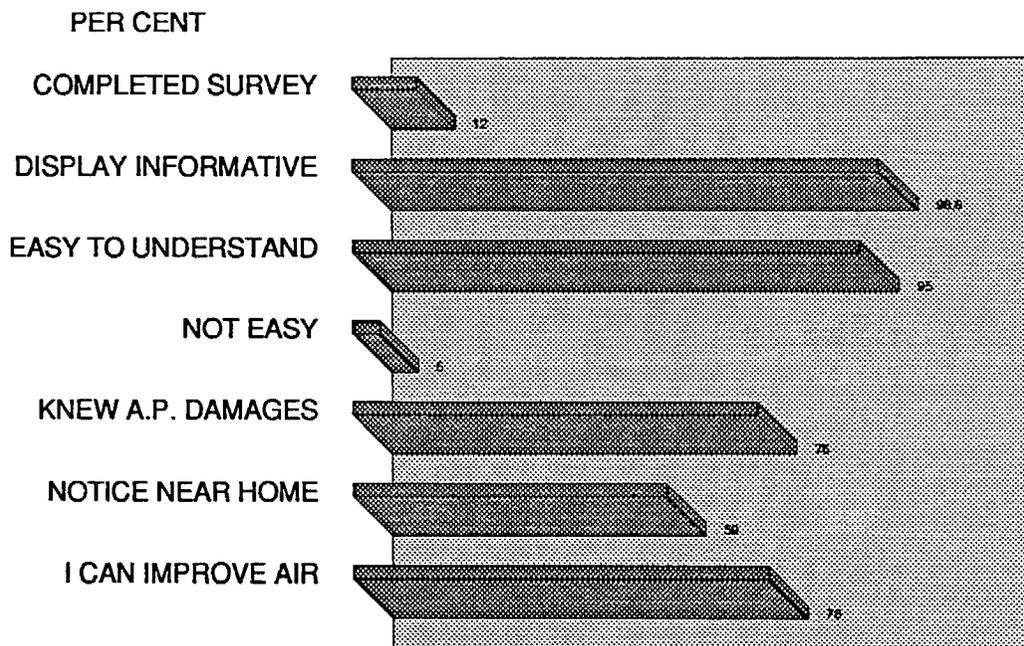
L.A. STATE AND COUNTY ARBORETUM, ARCADIA

Analysis of Questionnaire, 1989-1990
COMMENTS: POSITIVE AND NEGATIVE



L.A. STATE AND COUNTY ARBORETUM, ARCADIA

SUMMARY: Analysis of Questionnaire
HOW VISITORS ANSWERED THE QUESTIONS



L.A. STATE AND COUNTY ARBORETUM, 1889-90

**AIR POLLUTION GREENHOUSE
OUTREACH PROGRAM AND
MEDIA COVERAGE**

LOS ANGELES STATE AND COUNTY ARBORETUM, ARCADIA 1990-91

THE AIR POLLUTION GREENHOUSE OUTREACH PROGRAM AND MEDIA COVERAGE

IMPROVEMENTS TO EFFORTS TO INVITE MORE VISITORS TO SEE
THE EXHIBIT INCLUDED THE FOLLOWING:

The location of the greenhouse was included in the re-print of the map of the arboretum grounds visitors receive at the gate.

A brochure was designed and mailed to school districts and civic organizations.

Press releases to local television and radio stations resulted in coverage on Channel 4 NEWS KNBC-TV, Los Angeles.

Efforts were made to reach people who do not regularly read scientific Journals and articles appeared in SUNSET MAGAZINE LANDSCAPE & IRRIGATION, THE LOS ANGELES TIMES, THE HIGHLANDER and THE PLAIN TRUTH.

TEXT OF THE PRINTED MATERIALS FOLLOWS

1989
APRIL - OCTOBER
A SPECIAL EXHIBIT

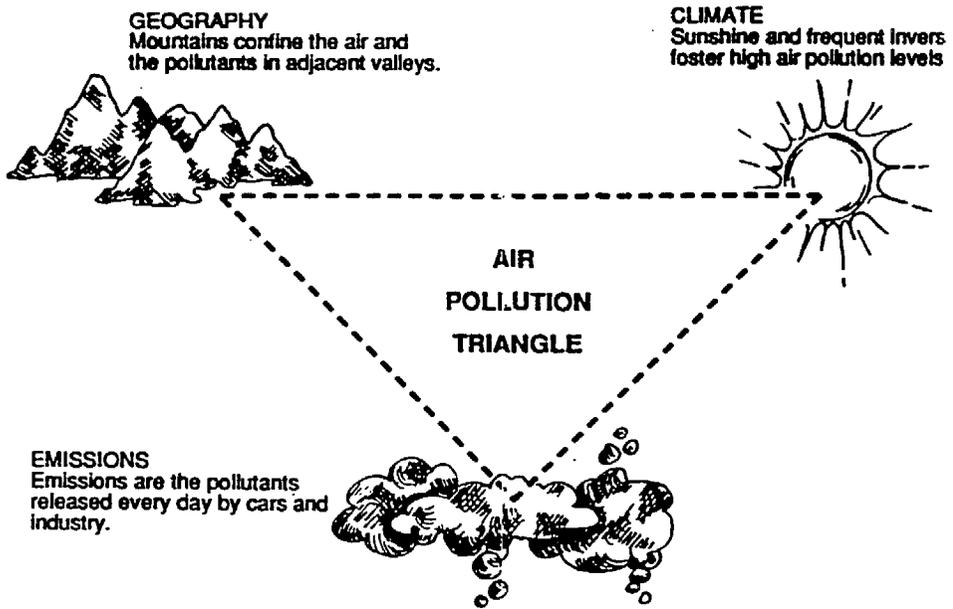
THE
AIR

POLLUTION
GREENHOUSE

Los Angeles State and County
Arboretum
301 North Baldwin Avenue
Arcadia, CA 91006

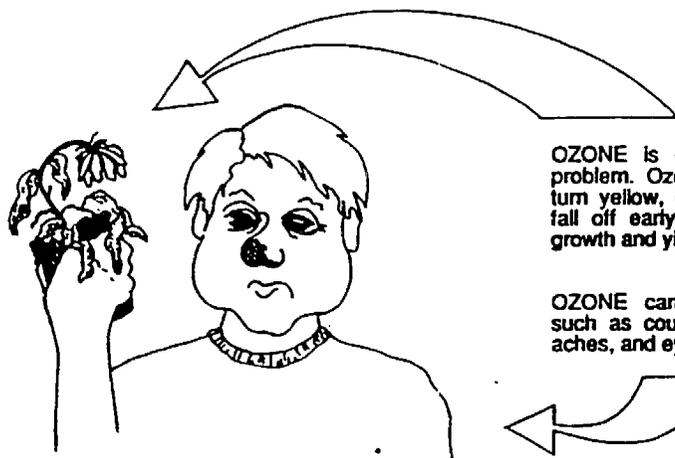
THE AIR POLLUTION GREENHOUSE is an educational display designed to demonstrate the effects of air pollution on plants. In the Interpretive building, posters around the room explain air pollution and the problems it creates. Operating equipment monitors daily pollutant levels.

Two greenhouses, side by side, contain identical types of plants at the same stages of growth. The air in the first greenhouse has been drawn from outside but circulated through charcoal filters to remove pollutants. The air in the adjoining greenhouse is the same as the ambient (unfiltered) air we breathe from outside. As you pass through the greenhouses, close inspection of the plants reveals marked differences in leaf size, leaf color, flower color and production, as well as overall hardiness.



VOCABULARY LIST

- | | |
|------------|--------------|
| Air | Geography |
| Ambient | Greenhouse |
| Arboretum | Hardiness |
| Charcoal | Interpretive |
| Circulated | Ozone |
| Climate | Pollutants |
| Emissions | Smog |
| Filtered | Unfiltered |



OZONE is our biggest air pollutant problem. Ozone causes plant leaves to turn yellow, develop dead areas, and fall off early. Plants suffer reduced growth and yield.

OZONE can cause health problems such as coughing, chest pain, headaches, and eye irritation.

The Air Pollution Greenhouse is located inside the Los Angeles State and County Arboretum, west of the Henry C. Soto Water Conservation Garden. This special display is open from April 1 through October 31 only, from 9:00 a.m. to 4:00 p.m. Unguided visits are welcome any time during these regular operating hours.

Special appointments can be made for schools and youth groups wishing to visit this exhibit by calling 818/446-8251, extension 17. For these visits, a staff member will be available to present a short introduction and to answer questions from the group.

The Air Pollution Greenhouse is sponsored by the California Arboretum Foundation, the Los Angeles State and County Arboretum, and the California Air Resources Board.

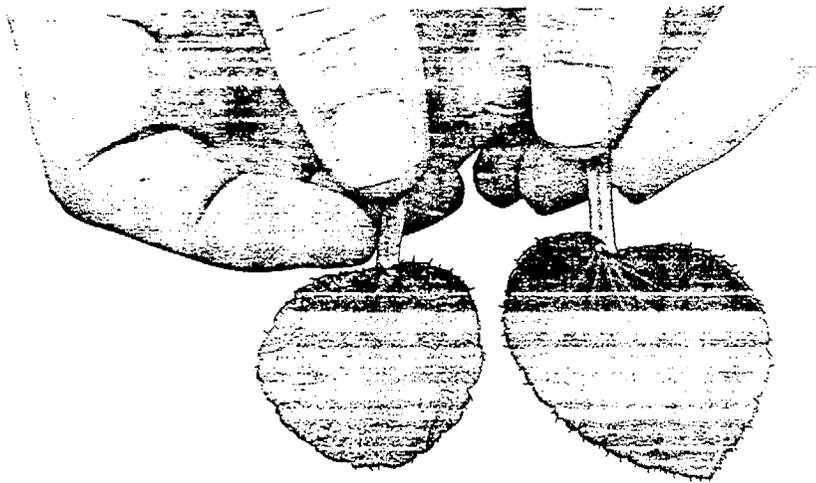
The Los Angeles State and County Arboretum is a 127-acre garden containing many areas of educational interest. In addition to the Air Pollution Greenhouse, plan your visit to include these other attractions:

- Henry C. Soto
Water Conservation Garden
- Prehistoric and Jungle Garden
- Garden for All Seasons
- Historical Section
- Tropical Greenhouse

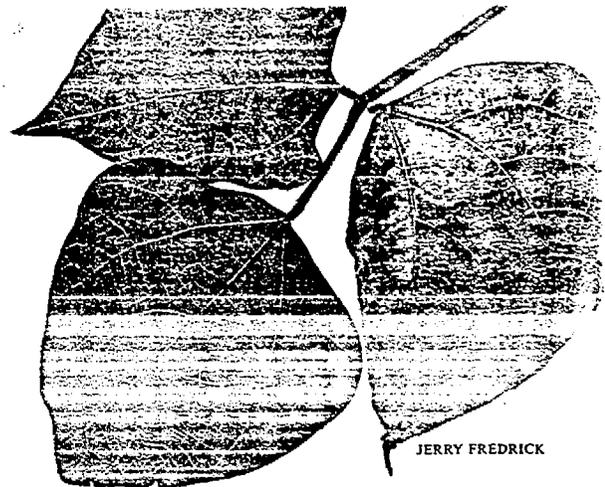
**LOS ANGELES STATE & COUNTY
ARBORETUM**

ADMISSION FEES

Adults	\$3.00
Senior Citizens (over 62)	1.50
Adults w/student ID	1.50
Children ages 13 to 17	1.50
Children ages 5 to 12	.75
Under 4 yrs.	Free
Tram Tours, all seats	1.50



Larger, even-toned fibrous begonia leaf had filtered air; otherwise, both grew under identical conditions



JERRY FREDRICK

Bean leaves show classic symptoms of smog disease: their normally dark green color is speckled

Does smog damage plants?

New Arcadia greenhouse tests show how.
But what can you do about it?

Los Angeles owns the dubious distinction of having some of the nation's most polluted air. San Diego's isn't much better. Poor air quality is a long-term problem; there's not much you can do about it today. But if you know which plants are most susceptible to smog, you may be able to avoid frustration and disappointment.

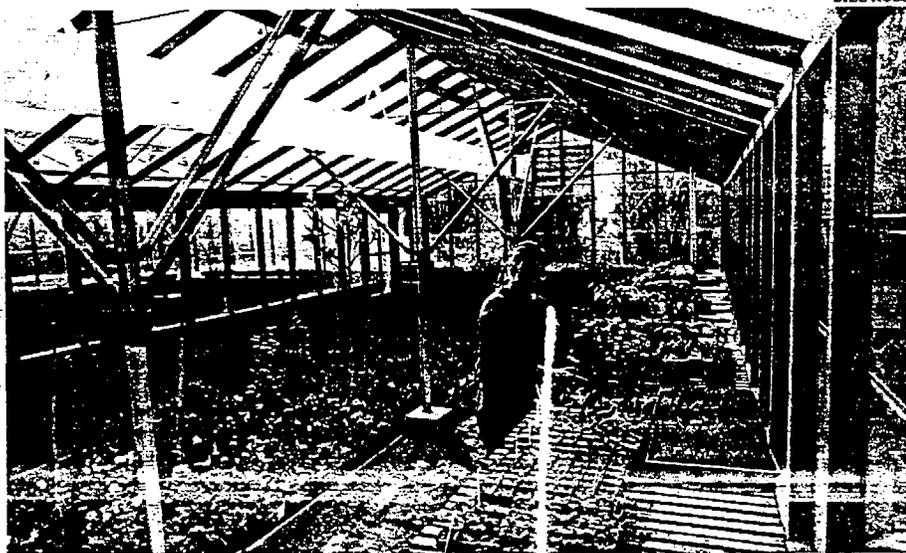
An experiment at the Los Angeles State and County Arboretum tests smog's effects. The same kinds of plants grow in two separate greenhouses kept at similar temperatures. Plants in both receive identical care. But one greenhouse receives regular outdoor air; the other draws outside air through a charcoal filter system that removes smog's major components.

The plants in the purified air have prospered, while most plants in the smoggy greenhouse showed some damage within a month; for example, white spots appeared between leaf veins on petunias. Other susceptible plants include begonias, calceolarias, carnations, corn, cucumbers, dahlias, marigolds, onions, parsley, spinach, and tomatoes.

Fortunately, many plants can resist smog's effects: succulents, New Zealand flax (*Phormium*), summer-flowering portulaca, and Bermuda and zoysia grass show no damage so far. All have small breathing pores (stomata), a typical drought-tolerant plant feature that may reduce the smog intake. Snapdragons and zinnias also seem resistant.

There's nothing you can do to help an affected plant recover. Washing off foliage won't prevent damage. But once you know smog is the culprit, at least you won't cause more injury by treating the wrong problem. Just keep plants healthy so perhaps they'll outgrow the damage.

You can see the test greenhouses 9 to 5 daily in the South African section at the arboretum, 301 N. Baldwin Avenue, Arcadia. Admission is \$3, \$1.50 seniors and students, 75 cents ages 5 through 12. □



BILL ROSS

Back-to-back greenhouses host identical plants that receive same care and grow at same temperatures; filtered air is only difference. Clean-air greenhouse below is serviced by two swamp coolers enclosed in sheet-metal housings



Plants vs. ozone: A battle for survival

Weekend gardeners who find their petunia and periwinkle plants keep pushing up, daisies should stop watering their brown thumbs.

And start blaming the brown sky.

Though smog is certainly not the only reason why some ornamental plants don't do well in the San Gabriel Valley, studies have shown it can damage these flowering plants, among others.

There is a (petunia) plant. It becomes silvery, and then it turns brown, explained Conrad Skimina, research director at Monrovia Nursery.

Skimina says the problems with petunias and ozone are so bad that he alters their growing season.

Instead of planting them in the summer, he plants them in November, when smog levels have subsided.

"At Easter, they will be blooming beautifully and you end up with a much nicer plant," he said.

They (leaves) premarily turn color and drop. Marigolds are another particularly susceptible flower, Skimina said. These suffer from discoloration that eventually drains the leaves of chlorophyll.

"The plants just look terrible after they've gone through weeks of smog," he said.

Ozone is a strong oxidant formed in the atmosphere when unburned fuels mix with nitrogen oxides from combustion from industry and automobiles.

Its effect on certain plants is comparable to pouring chlorine bleach directly on clothes.

"It bleaches the (plant) tissue. You are actually damaging the tissue and the cell walls," Skimina said.

Ornamental trees — like the ones found in back yards — also suffer from "breath- ing" too much ozone.

Backyard sycamores are particularly prone to ozone stress, Skimina said.

The tissue between the leaves and the stem hardens, cutting off nutrients to the leaves, which drop off.

Skimina said, "I can see it in 24 hours on a (petunia) plant. There is the silvery of a leaf. It becomes silvery, and then it turns brown," explained Conrad Skimina, research director at Monrovia Nursery.

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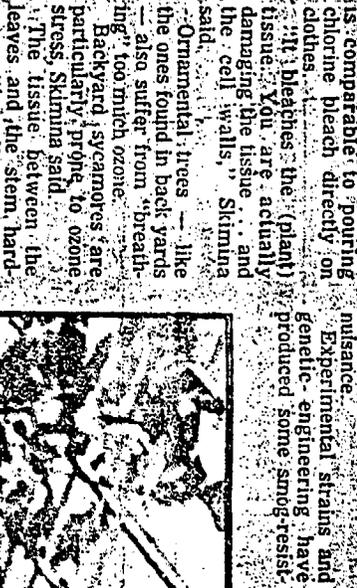
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The colors on the left, grown in smog, is paler and less vibrant than the one at right that was grown in a filtered air green house.



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Staff photo by Richard Hormann

¹⁵⁶⁶
Polluted plants: Arboretum publications specialist LuAnn Munns examines two plants from greenhouses at the park which study the effects of ozone on green plants and flowers. The greenhouses are part of an exhibit at the Arcadia gardens that will be open to the public through October

Impact of smog on plants to be studied

By Richard Hormann
Staff Writer

Most Southern Californians are all too familiar with the effects of air pollution. Watery eyes and shortness of breath are symptoms shared by those who find themselves at the mercy of the toast-colored air that tends to hover above the basin on hot, summer afternoons.

But what about plants? What impact does smog have on your garden?

Researchers at the Los Angeles State and County Arboretum aren't beating around the bush on this topic, but instead are hoping to turn over a new leaf in their studies of effects of air pollution on plants.

Two greenhouses, each containing the same types of plants in identical planting schemes, are being monitored by officials at the Arcadia park and California Air Resources Board who have created two very different environments for the vegetation.

Charcoal filters are being

used in one of the shelters to purify the air by removing up to 90 percent of the pollutants locked beneath the basin's inversion layer. In the second greenhouse, plants are exposed to the same air you and your garden are surrounded by each day.

The result is a seven-month long exhibit open to visitors who can examine the impact of smog on plants.

This is the third year the twin greenhouses have been used for the project which, officials say, continues to yield evidence supporting their belief that pollutants — primarily ozone — affect the texture, growth and reproduction of plants.

"It's purely an educational exhibit," said John Provine, who oversees the park grounds. "The Air Resources Board just wants more people to be more conscious of our environment and our air."

According to the board's estimates, California farmers may be losing up to \$1 billion each

See ARBORETUM/8

Arcadia Highlander

ARBORETUM

¹⁵⁶⁶
Continued from page 3

year from crops damaged by smog. The point of the project, Provine said, is to make people more aware of this, not to prompt fear among those who might worry about smog damage to their health.

"The whole purpose is to try to show what (type of research) they're doing," he said.

A computer in a room adjacent to the shelters monitors the amount of ozone in both greenhouses and produces a constant printout of smog levels throughout the day.

Ironically, Provine said, the air quality in Los Angeles has been too good this season to have any detrimental effects on the plants.

In fact, he said, the smog level has been so low this year that co-researchers from the University of California Riverside

STUDY:

"will shoot the plants with gas to give it the same effect as smog would."

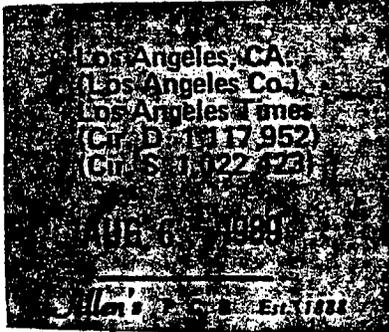
Surprisingly, officials are actually hoping for more of the real thing.

"Hopefully, we won't have to (gas them) much longer," Provine said.

The park administrator reminisced about the first program of this type in 1987, which provided dramatic results. From dead, brown palm frond edges to flowers only a fraction of the size of those grown in the filtered greenhouse, Provine said he was pleased with the results, and all thanks to the unlikely contributor.

"The smog made it one of the best seasons we've had," he said.

The exhibit is scheduled to run through October, and is included in the price of admission into the Arboretum.



Air Pollution Effect on Plants Shown

1564
Twin demonstration greenhouses where plants illustrate damage caused by air pollution are on view through October at the Los Angeles State and County Arboretum at 301 N. Baldwin Ave., Arcadia.

Visitors to the Arboretum can walk through the greenhouses to observe the effects of air pollution and how smog damage varies among plants, said Arboretum superintendent John Provine.

In one greenhouse the air is pure, 90% of the contaminants have been removed by charcoal filters. The other greenhouse contains the same, often unhealthy, air that visitors breathe.

C. Ray Thompson and Gerrit Kats of UC Riverside have served as consultants on the project since it was initiated in 1986. The greenhouses are educational displays, and a new computer screen attached to the smog monitor shows information in color graphics.

According to nursery workers at

the Arboretum, camellias, miniature roses and pansies show little smog damage. Other resistant plants include succulents, oleanders, geraniums, junipers and hi-

biscuses; on the other hand, petunias suffer the most and damage to leaves and flowers is usually visible a couple of weeks after a smog alert.

Greenhouse Maps Smog Effects on Plant Life

By LAURIE K. SCHENDEN,
Times Staff Writer

So we laugh about Michael Jackson's "sleeping chamber" filled with purified air, and called Howard Hughes a fanatic for living in a sterile environment. But the question most often asked around the smog-free greenhouse at the L.A. Arboretum is, "How can I get one of these systems for my home?"

The inquiry is understandable after you've looked into the greenhouse—filled with robust plants—which by no coincidence is next door to a greenhouse with normal air. The plants in the regular greenhouse are smaller; some of the leaves are brown, discolored or curling, and the plants themselves are weaklings compared to those dwelling in the smog-free environment. The startling thing is, the struggling plants in the regular greenhouse are breathing the same air we do.

The smog-free greenhouse is part of an educational project in its third year at the Los Angeles State and County Arboretum. Funded by a grant from the state Air Resources Board, officials in Sacramento are keeping close tabs on the progress of the plants, receiving photographs every month of plants from both greenhouses to see what effect smog is having.

Air Is the Variable

Though its greenhouse is mainly an educational display, not a research project, the Arboretum has been able to determine when smog is detrimental to certain plants because the only variable is the air. The young plants that are put in the greenhouses are identical, all started in the propagation area in the nursery and put into the filtered air as 2-inch plants. When the roots are established (4 inches), they are separated, six plants in the filtered air, six in regular air.

There are about 32 kinds of vegetables and bedding plants and 20 different trees and shrubs in each greenhouse. They are given the same amounts of water, fertilizer and care. With the aid of the filtering system, the smog-free greenhouse has the impurities (i.e. pollution) taken out.

A monitoring system outside the greenhouses detects the ozone and nitrogen dioxide levels of the ambient air (smog-free house). There are also photographs of healthy plants and of plants affected by the smog in a display nearby.

"Some plants do better than others [in smoggy conditions]," says June Petrie, a student of ornamental horticulture who works in the greenhouses. "Like bush beans, within the first four weeks you can see a difference. Petunias, begonias and zinnias—a lot of the bedding plants people use all the time—are greatly affected by the smog."



ROBERT GABRIEL / Los Angeles Times

June Petrie demonstrates effects of smog on plants to visitors at L.A. County Arboretum.



Plant at left grows in "normal" smog, while plant at right breathes filtered greenhouse air.



Pinto bean plant nurtured in filtered air is free of spots and damage from Los Angeles smog.

The plants chosen for the project are often those suggested by visitors, who fill out questionnaires. "It's not meant to tell people what plants to grow," says John Provine, Arboretum superintendent. One request came from UC Riverside to test the Washington palm.

"They were noticing yellow blotches on the fan palms and they weren't sure what was causing them," recalls Provine. "They asked if we'd try it, and sure enough; they both started out in the clean air, and the one in smoggy air developed the spots."

The smog has, in fact, affected the area's economy. "The L.A. area used to be a hotbed for spinach," says Provine, who has worked at the Arboretum since 1958. "Spinach used to be grown on a large scale here, but you can't have spotty, blotchy spinach on the market."

Smog also drove away flower producers, Provine says. "A lot of growers moved out—orchid growers moved to Santa Barbara and the coastal area, because the flowers were getting blemishes here, so they weren't salable."

Though the project has proven that smog is often the culprit when there's a problem with a plant, smog damage isn't always easy to detect.

"If you saw this [shriveled leaf or blotches] in someone's garden you wouldn't say, 'Oh, that's pollution damage,'" Petrie says. "It's not always that obvious. But people come in and say, 'Oh, now I know what's wrong, it's not an insect or a disease, it's the smog.'"

But the real benefit of the greenhouse experiment, Provine says, is that "we're finding out plants aren't looking the way they're suppose to look."

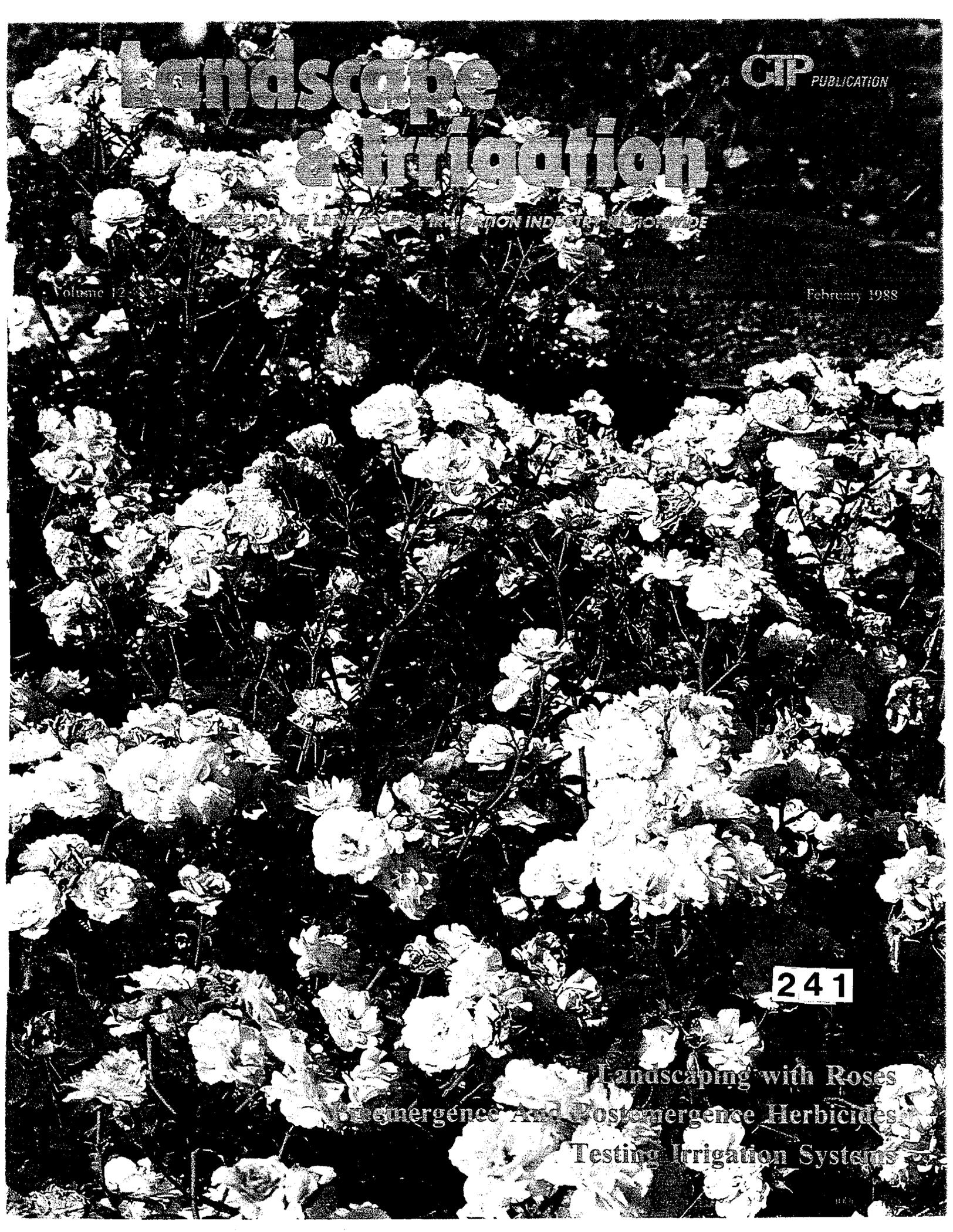
Another question often asked after a stroll through the greenhouses is, "What can be done?"

"Car pooling," Petrie answers. "People have to say to themselves, 'We're the next step.'"

"There's nothing that replaces the visual impact," Petrie adds. "When people can see there's less vigor, less flowering [in the normal air], it's sobering."

"Sometimes people are afraid to go into the smoggy air," Petrie says, "but what some don't realize is that it's the same air they're breathing every day. We don't need to put any more pollutants in this house. The air comes from right outside."

The project, which began in April, runs through Oct. 31, when the effects of smog are the most noticeable. L.A. State and County Arboretum, 301 N. Baldwin Ave., Arcadia.



Landscape & Irrigation

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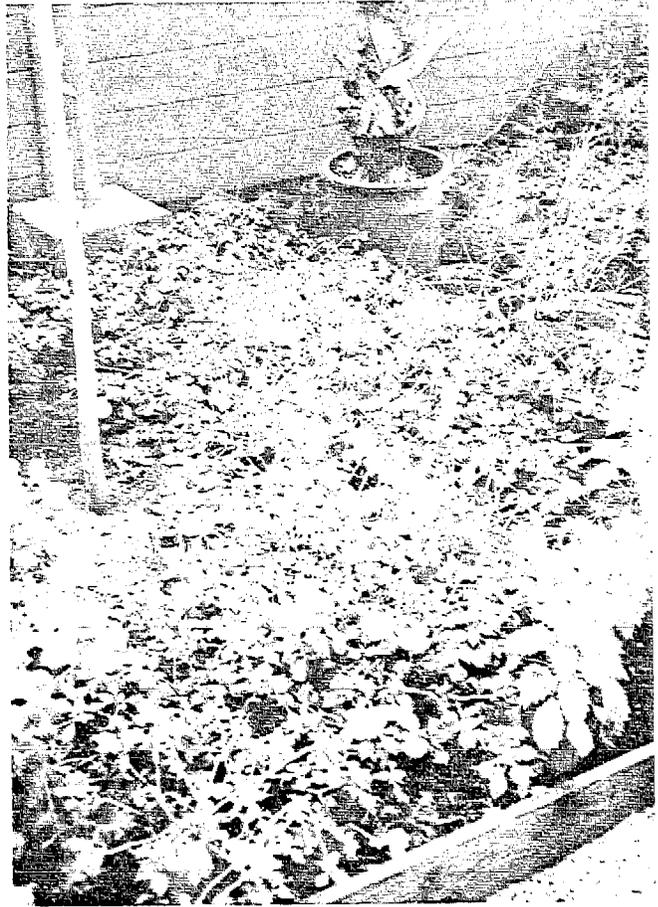
Volume 12, Number 2

February 1988

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Landscaping with Roses
Preemergence And Postemergence Herbicides
Testing Irrigation Systems

The Effects Of Ozone On Landscape Plants



Busy Lizzie Impatiens growing in greenhouse open to the ozone-laden atmosphere.



The same Busy Lizzie Impatiens growing in filtered air.

From the deepest heart of Smogville—California's choking, coughing San Gabriel Valley, northeast of Los Angeles—has come graphic visual evidence of just how badly ozone, the prime component of smog, can and does damage landscape plants.

Wherever you may live and work in these United States, don't make the mistake of thinking, "It can't happen here." If you inhabit an urban area with factories and cars, as most of us do, you may be next.

When the ozone level in the air exceeds .12 parts per million, it's officially a smoggy day. With an average of 175 such days per year, the Los Angeles area admittedly does lead the nation in ozone.

However, Houston, TX, with 50 smoggy days a year, is currently running second to Los Angeles. San Diego is third, so count two out of three for California. However, New York City, across the continent, is the fourth smoggiest city in the United States. Chicago, IL, the most midwestern of cities, runs fifth in smoggy days. Clearly the ozone problem is not limited to California or the West.

To see the dangers of ozone at their worst, however, there's no place like America's smog capital, Southern California. A visit to the twin "smog-demonstration" greenhouses on public display at the Los Angeles State and County Arboretum in Arcadia, CA, is

enough to turn any landscape contractor from a disbeliever in the damaging effects of ozone to a concerned convert determined to do something about the situation.

The general public may simply see grievously disfigured plants and turn away. However, the dollars-and-cents damage to those plants, a landscaper's stock in trade, is graphically evident for all contractors to see.

The greenhouses will open for the second year of a three-year demonstration on April 1, and will be open until October. This year several additional landscape plants will be featured, and a number of grasses as well.

Side by side they sit—one greenhouse open to the ozone-laden atmosphere, the other using filtered air exclusively. Mirror-image plantings of identical landscape and home-garden plants are laid out in identical floor plans, so that they can easily be compared to show the harmful effects of smog in the unprotected greenhouse. The results are startling, as shown by the accompanying photos.

The primary villain is ozone. A pungent, colorless, yet highly toxic gas that works incredibly fast to do its damage to plants and humans, ozone constitutes more than 95 percent of smog. It is formed in the lower atmosphere, when emissions of hydrocarbons, such as unburned automobile fuel and industrial-process vapors, react in sunlight with products of combustion known as oxides of nitrogen.

Dahlia Hybrids

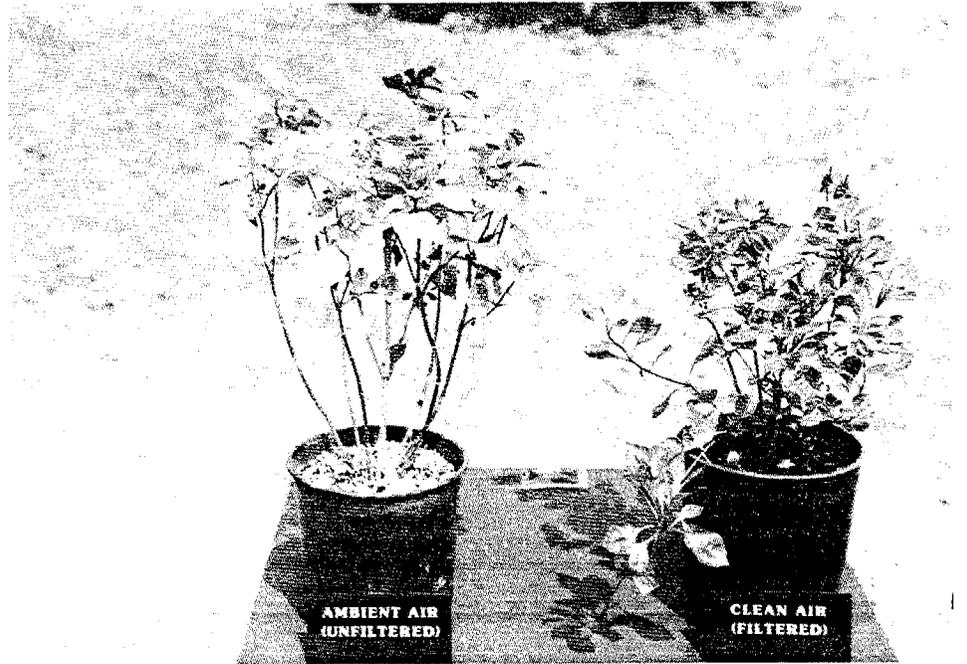
Motor vehicles account for 34 percent of hydrocarbon emissions and 45 percent of oxides of nitrogen emissions in the United States. Power plants, oil refineries, industrial processes, and other sources account for the rest.

When these pollutants combine in sun-

light, the resultant ozone is very unstable and rapidly causes oxidation—a type of rust—on such varied surfaces as metals, paints, and landscape plants, harming or even destroying them all.

Gerrit Katz, an air-pollution researcher at

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The Effects of Ozone

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the University of California at Riverside, explains just how ozone does its insidious and rapid damage to plants: "The ozone enters the stomates—the small apertures on the leaf surface of the plant. And it follows the same pathway where all the other gas exchanges take place." These others are beneficial exchanges, necessary to the life of the plant.

Ozone is a very strong oxidizer, so it affects the membranes of the cells within the leaf whose stomates it has entered. These cells play a very important part in the plant's metabolism.

"Ozone is actually supercharged oxygen, and not very stable," Katz explains. "It's the same ozone that causes cracking of your rubber tires and oxydizing of your car paint—it's very reactive. So it goes into the delicate plant mechanism and affects the biochemistry of the plant."

The ozone accomplishes this by killing the cells with which it comes in contact—all the membrane cells around it, in other words. And when these membranes are damaged, they die. This prevents the beneficial gas exchanges that keep the plant alive and growing from taking place, so the plant starts to die, too.

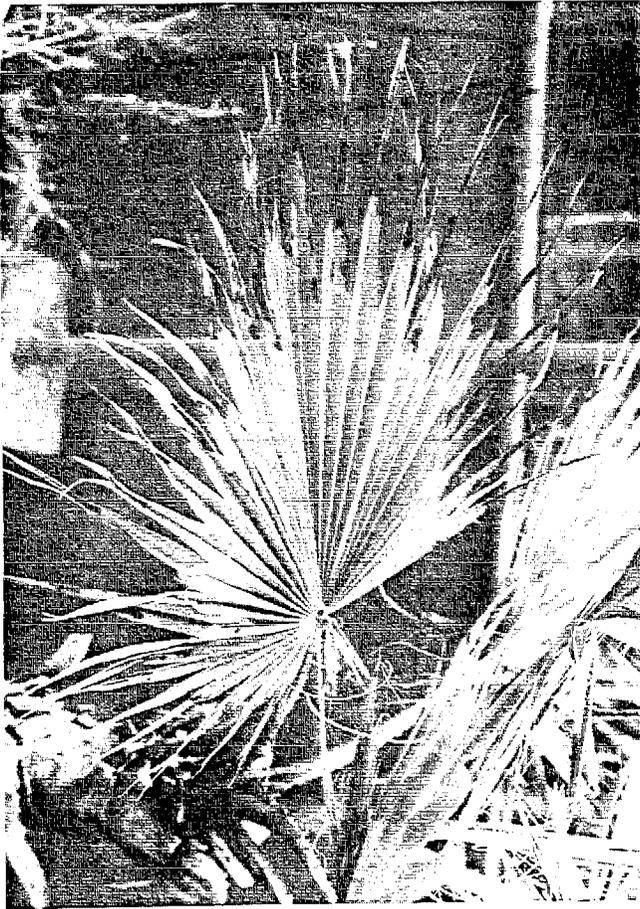
Katz reveals that ozone at a very high level "almost causes an instant wilting, because it robs the plants of the ability to hold their water." Fortunately, he adds, some plants have much better ability than others to resist ozone, because their stomates, or leaf openings, are smaller. So they are better able to keep the toxic gas out of their inner workings.

Contractors in smoggy areas of the country who don't want to risk having their plants wither and die within days or weeks of installation should keep a list of these ozone-resistant plants, which Katz describes as follows. (More will be mentioned later in this article.)

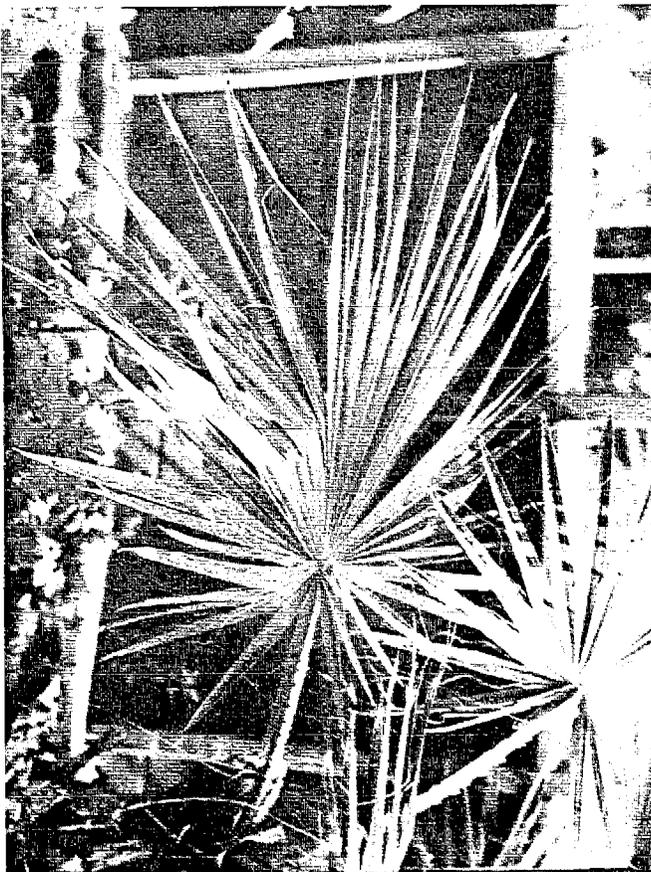
"Succulents are all right," says Katz. "New England flax is fine; I've never seen it exhibit any symptoms. Marguerites are okay. Marigolds are okay. Calendula are all right—they're like a golden-orange daisy. And portulaca, a small succulent, is fine for summer, when smog is most likely to appear."

However, it is ozone-susceptible plants that make up the plantings in the demonstration greenhouses at the Los Angeles Arboretum. The display was prepared, with financing from the California Air Resources Board, to alert the citizenry to the intense harm caused by ozone when it attacks landscape and garden plants. The goal is to get people to urge their elected or appointed representatives to do more to prevent and combat ozone-laden air pollutants and all their harmful effects.

Gloria Shams, a horticulturist at the arboretum, helped prepare the demonstration greenhouses and is currently selecting more landscape plants for the 1988 season. She believes that all landscape contractors who



The California Fan Palm in the ambient house was yellow and edges of the fronds were actually blackened.



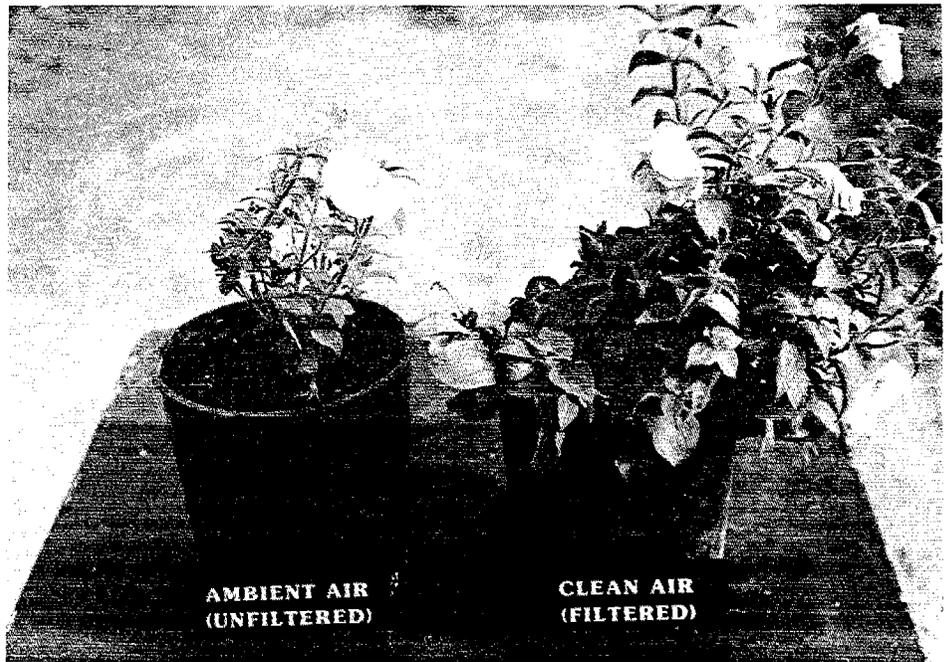
In the filtered house, the leaves were green and didn't show any ill effects.

live in or visit the area this year or in 1989 should make a point of visiting the two greenhouses. Many contractors' profits can be severely affected by air-pollution damage to the plants they buy, sell and install in landscapes.

Those who are fortunate enough to live and work in areas of the country not presently menaced by ozone destruction of plants should not ignore the future risk of creeping pollution. They may well be motivated by the display to seek preventive measures to keep the air in their areas clear of ozone or other potential pollutants that threaten the welfare of plants. And those who live in smog areas will come face-to-face with the destruction that even now threatens their own plants.

"Because of the lifestyle that we have in our urban society, plants are sometimes our only contact with nature," Shams observes. "Unfortunately, we are polluting the plants around us with auto exhaust and factory emissions.

"We wanted to show the public the effects of air pollution on plant growth, by putting up these two demonstration greenhouses," Shams continues. With a \$62,934 grant from the Air Resources Board, they were able to do so in 1987. "We're not doing any research here—it's strictly a demonstration project—but pollution researchers like Dr. Katz at UC-Riverside and his colleague, C. Ray Thomp-



Petunia Hybrid

son, have helped us by acting as consultants."

The comparative results in the two side-by-side greenhouses can be startling to the beholder. Shams cites many examples of

ozone damage to the plants in the "ambient-air" greenhouse—the one whose unfiltered air is the same as all other plants in the area have to live—or die—in. The arboretum sits

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The Effects of Ozone

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in the very heart of the San Gabriel Valley, where the ozone level in the summertime is very high—about as high as it ever gets in the United States.

Prior to going on display, all plants were brought to the same level of development with filtered air, so that those in each greenhouse would have an "even start." However, once the plants in the ambient-air greenhouse began to "breathe" the ozone, very disturbing things began to happen.

Among the main sufferers in that smoggy greenhouse were the petunias. "They showed damage almost right away—within the first two weeks. They had irregular white spots on their leaves," Shams reports. "People would look at them and say, 'I don't want that plant in my yard!'" The white petunia, it turns out, is the most ozone-susceptible of all common bedding plants.

"Sunflower also shows damage pretty quickly—probably within the first month or so," Shams reports. "It has the same type of very white, irregular shapes on the leaf."

The damage to marigolds showed up as very small, pin-sized dots that were yellowish. "We had to look really close to see the damage," says Shams. "It wasn't very obvious until you looked for it."

The western catalpa showed the same yellow, pinpoint-sized spots as the marigolds. On both plants, Shams emphasizes, "the spots don't go through—they're not pinholes. And you can see more on the top side than on the bottom."

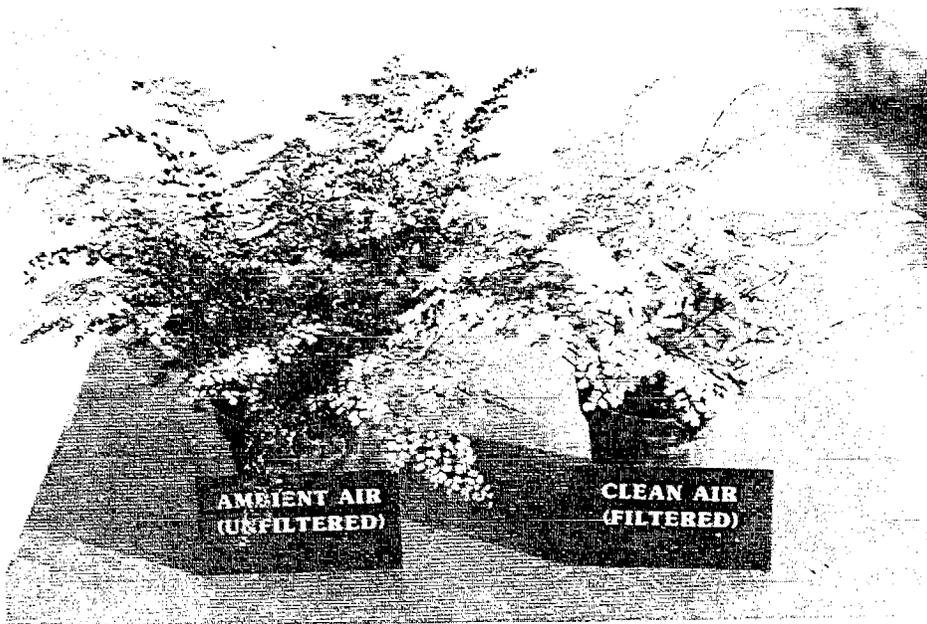
One thing she noticed with the coleus was that plants grown in the "filtered house" had a more vibrant color than those in the "ambient house," as the photos show.

Dead zones were clearly seen on the leaves of many of the plants tainted by ozone. "On the dahlias there were vast amounts of dead brown area between the leaf veins," Shams explains. In the ambient-air begonias, the leaves also had these dead, brown areas, the plants were smaller, and there were half as many leaves on the plants as those in the filtered house.

Slipper flowers from the ambient house had "a scorched, brown look on them, whereas those grown in the filtered house were a beautiful, lettuce-green color," Shams reports.

Later in the season, the browallias showed significant ill effects from air pollution. Those grown in the filtered house were full, very green in color, and had many flowers. The plants grown in the ambient house had lost probably 90 percent of their leaves, had significantly fewer flowers, and were also smaller. "They were basically spindly-looking, whereas the ones in the filtered house were full and lush," Shams observes.

A California fan palm was placed in each greenhouse to show the effects of air pollutants on this often-used landscape plant. The fan palm in the ambient house was yellow, not green, and the edges of the fronds were actually blackened. In the filtered house,



Maidenhair Fern

Once the plants in the ambient-air greenhouse began to "breathe" the ozone, very disturbing things began to happen. Among the main sufferers in that smoggy greenhouse were the petunias. They showed damage almost right away - within the first two weeks. The white petunia, it turns out, is the most ozone susceptible of all common bedding plants.



Begonia

on the other hand, the leaves were the natural, normal green and didn't show any ill effects at all. So it was obvious that this particular palm, popular with many landscape contractors, does have a definite adverse reaction to pollutants in the air.

"Some of the plants in the ambient house did not show any *obvious* effects from pollutants," Shams reveals. "But sometimes it comes down to measuring and comparing root growth, which we did not do, since these plants were for demonstration and not research."

On a more positive note, in both greenhouses "we had spider plants, a creeping philodendron, and the schefflera. These three plants are thought to purify air indoors," Shams observes. Again, there was no research done to prove this. If true, the purification efforts of these three "good samaritans" were quickly overcome by the ozone in the ambient house.

For reference purposes, but not as plantings, Shams has a list of plants that are harder than the ones in the greenhouses. They are taken from a book called "Air Pollution Injury to Plant Life," by Donald H. Scott. Most of the plants it lists as ozone-tolerant are trees, such as European white birch, white dogwood, European mountain ash, Douglas fir, Norway maple, sugar maple, and several oaks and spruces.

However, its ozone-tolerant list also mentions bermudagrass, zoysiagrass, and arbor-

"At a very high level, ozone causes an almost instant wilting because it robs the plant of its ability to hold water."

vitae, which includes both trees and shrubs. This book has many lists of plants that are either sensitive or tolerant to various pollutants around the country, and is recommended to those who would seek further guidance in this respect.

"This year we will be putting in more plants that are very common in landscaping, such as gazanias," says Shams of her plans for the 1988 twin-greenhouse demonstrations at the arboretum. "If a landscape contractor came in and viewed these plants, he or she would be able to get an idea as to which plants might be relatively better or worse in a landscape situation, depending on what the landscaper sees there.

"Since the plants were mainly chosen for smog susceptibility, however, they will primarily learn which plants to *avoid*, because of the problems that might arise from putting in those plants and then, one or two weeks

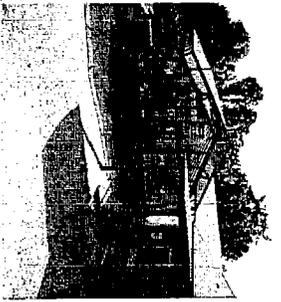
later, having to take them out again because they are doing poorly.

"Again, the classic example is petunias. Around here, you can buy them from the nursery, and even before you get them into the ground, they can start to show damage from air pollution," Shams cautions. "I myself bought some white petunias for use in a display garden—not one of these two demonstration greenhouses. I was not able to put them into containers for a week. And by then I was unable to use them, due to the damage they had already suffered from air pollution during that one week!

"This year I'm going to use one or two types of grass in the greenhouse—probably some sort of bermuda and some basic type of bluegrass. I want to see if they show any problems from pollution damage. We will also be using a type of juniper. And this year we'll use roses and bougainvillea. I just thought using more of the popular landscape plants would be of interest to the public."

Certainly it should be of even greater interest to landscapers. So if you're in Los Angeles County between April and October, either this year or next, be sure to drop by the Los Angeles State and County Arboretum. Take a close look at the comparison plantings in the ambient and filtered-air greenhouses, plus the adjacent photographic display of ozone damage to plants.

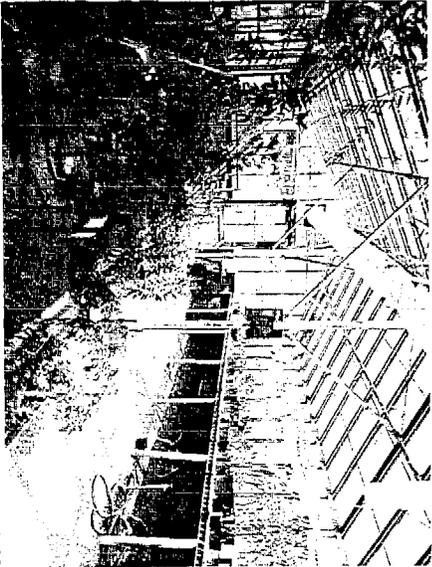
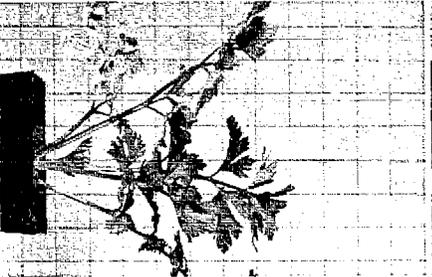
What you see there may shock you—but it could help you as well. □



AIR APPARENT

THese striking photos evidence air pollution's persistence at the Los Angeles Arcadium air-pollution greenhouse (left) in Arcadia, California, the photos compare plants grown in purified air to plants grown in the air Southern Californians breathe.

The greenhouse contains two rooms. Light, temperature, soil, irrigation and pest control in the rooms are the same. But in the first room (photos on opposite page), charcoal filters cleanse the air of impurities such as ozone. In the second room (photos below) is ambient (unfiltered) air.



Ray Meach, Smith

Notice how unfiltered air stunts cycloamen blooms.

The difference between the two rooms is obvious to anyone who steps into the filtered-air room and simply breathes. It's a joy to do so—the smell, taste and feel is completely refreshing. You just want to stay there. Then you realize, with disgust, how bad the air you normally live in really is.

Cars and factories mainly create the complex mix of chemicals in air pollution (smog). Ozone, the main component of smog, forms in the air when hydrocarbons and nitrogen oxides react in sunlight. A high-energy molecule, ozone (O₃) collides with and destroys living tissue. It enters plants through stomatal openings.

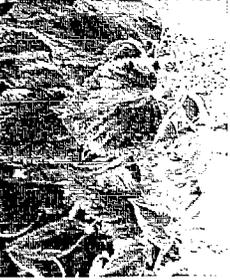
In humans, ozone, California's—and other regions—digest

air-pollution problem, scars and damages the lungs.

Other air pollutants include sulfur dioxide, carbon monoxide (produced by motor-vehicle combustion) and hydrocarbons from incomplete combustion of gasoline and evaporation of petroleum fuels and dehydratives). Children in California's South Coast Air Basin suffer a 10 to 15 percent loss in lung function compared to children breathing cleaner air.

The wind in the area also carries factory- and freeway-spawned pollutants to agricultural areas, where they damage plants and interfere with photosynthesis.

As early as the 1950s, smog was damaging crops near Bakersfield and Fresno in California's central valley region. A decade later smog damage became apparent in most of the state's farming regions.



January, 1974

California agriculture loses upward of \$1 billion a year to smog damage. And crops such as spinach, celery, lettuce, tomatoes, string beans and cucumbers cannot be grown commercially in and around Los Angeles County.

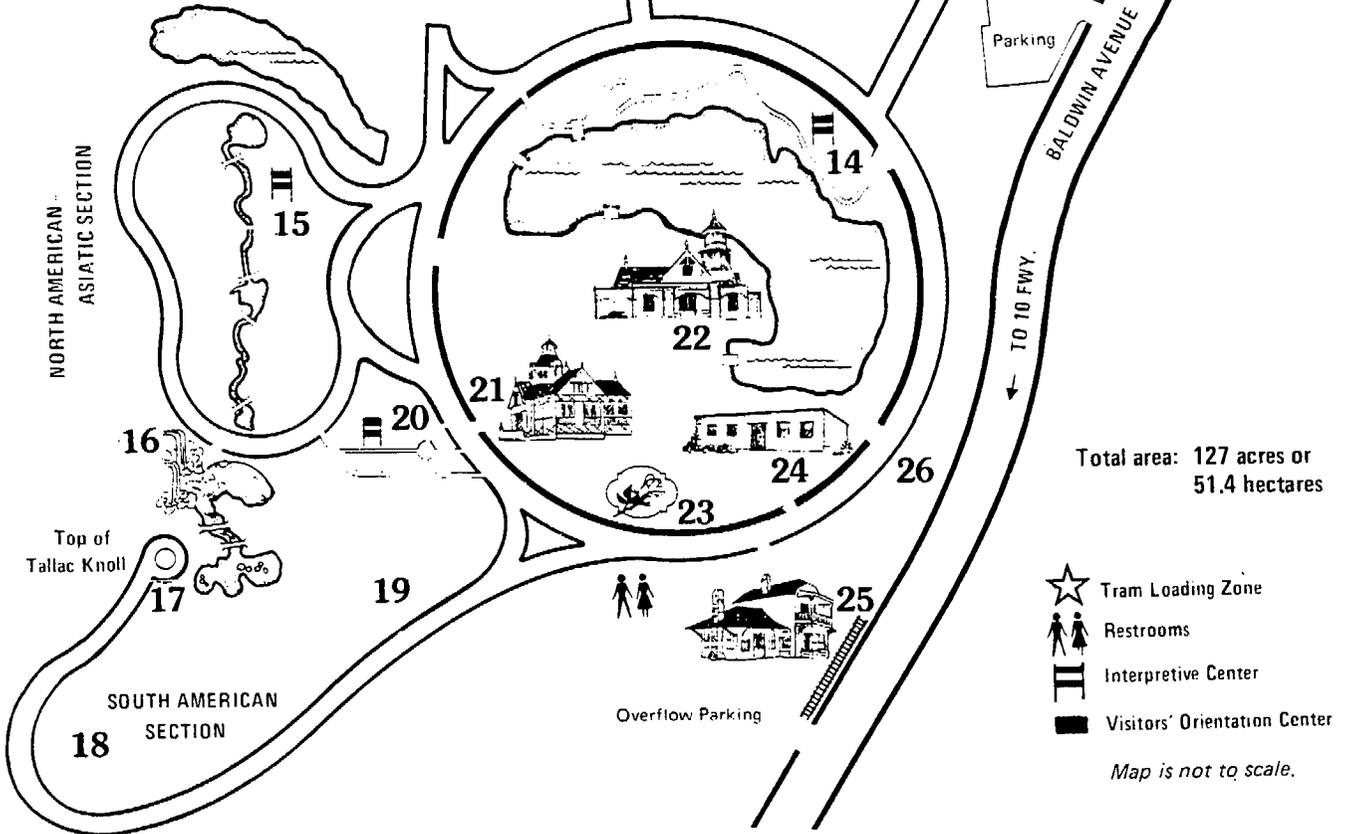
Air pollution forces many growers out of California altogether. Smog in the rapidly developing San Joaquin Valley, California's richest growing area, may soon be worse than in Los Angeles.

Air pollution also ravages trees and wilderness as far north as Yosemite National Park in central California. And around the world, overpopulated and overindustrialized urban areas—Mexico City, Manila and cities of Eastern Europe, for instance—face their own air-pollution crises.

Norman and Pamela Shoaf



1. ENTRANCE
Admissions, Lost & Found
2. Administrative Offices
Seminar Room
3. Education Building
Library
Lecture Hall (lower level)
4. Groundcover Display
5. Sunset Demonstration Home Gardens
6. Ayres Hall
7. Jumper Collection
8. Garden for All Seasons
9. Greenhouse Complex
Shade Garden, Begonia Greenhouse,
Tropical Greenhouse, Orchid Collection
10. Research Building
Herbarium
11. Australian Section - eucalyptus, acacia.
12. African Section - aloe, gerbera, groundcovers
13. Peacock Pavilion Coffee Shop
California Arboretum Foundation (lower level)
14. Prehistoric and Jungle Garden - cycads, azalea
15. Meadowbrook
Koi pond, deciduous magnolia, iris
16. Waterfall
17. Top of Tallac Knoll
Aquatic Garden, hibiscus
18. South American Section
19. Native Oaks
20. Herb Garden
21. Coach Barn
22. Queen Anne Cottage
23. Old-fashioned Rose Garden
24. Hugo Reid Adobe & Indian Wickiups
25. Santa Anita Depot
26. Palm and Bamboo Collection
27. EXIT
Gift Shop, public telephone



LOS ANGELES STATE AND COUNTY ARBORETUM

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