EPA-R5-72-010
October 1972

Socioeconomic Environmental Studies

# 1971 Survey And Assessment Of Air Pollution Damage To Vegetation In New Jersey

U.S. Environmental Protection Agency
Washington, D. C. 20460

EPA-R5-72-010

# 1971 Survey And Assessment Of Air Pollution Damage To Vegetation In New Jersey

by

Alberto Feliciano

Department of Plant Biology
Cooperative Extension Service
College of Agriculture and Environmental Science
Rutgers - The State University
New Brunswick, New Jersey 08903

Contract No. 68-02-0078
Program Element No. A11004

Project Officer: Donald G. Gillette

Office of the Director
National Environmental Research Center
Research Triangle Park, North Carolina 27711

Prepared for

OFFICE OF RESEARCH AND MONITORING
U.S. ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D. C. 20460

October 1972

## EPA REVIEW NOTICE

This report has been reviewed by the Environmental Protection Agency and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

TABLE OF CONTENTS

## ACKNOWLEDGMENTS

The work reported herein was performed pursuant to Contract No. 68-02-0078 with the Division of Ecological Research, Environmental Protection Agency, National Environmental Research Center, Research Triangle Park, North Carolina, and financed in part by Division of Rural Resources, New Jersey Department of Agriculture.

Grateful acknowledgment is extended to Dr. Robert H. Daines, Dr. Spencer H. Davis, Dr. John Springer, Professor Eileen Brennan and Professor Ida Leone of the Plant Biology Department, Rutgers - The State University for their valuable advice and assistance during the entire period of the survey. Special thanks are expressed to Professors Eileen Brennan and Ida Leone for the chemical tissue analyses. I also would like to thank the members of the Cooperative Extension Service of Rutgers - The State University for their cooperation during the survey.

Appreciation is also expressed to those members of the New Jersey Department of Agriculture, Division of Plant Industry who participated in the survey on nurseries, and to the New Jersey Crop Reporting Service for providing the necessary information needed in the assessment of crop losses. The cooperation of the Department of Meteorology of Rutgers - The State University in providing weather reports pertinent to possible air pollution episodes is gratefully acknowledged.

## ABSTRACT

A survey of injury resulting from air pollution episodes and assessment of their resultant effect on crop production in 1971 was conducted in New Jersey with the assistance of the Cooperative Extension Service and the Department of Plant Biology of Rutgers University. This survey was concentrated in the central and southern counties of the state where most of the agricultural crops are grown.

Economic loss to crops due to air pollution was estimated at $1,183,800. Indirect losses such as growers' relocation cost, crop substitution losses and loss in value of the land were not included. Likewise, economic losses to forest trees and other ornamental plants and reduction in crop yield due to invisible injury were not included.

Three hundred fifteen reported air pollution incidences were investigated and documented during the period of this survey. Plant injury was observed in 17 counties but economic loss or crop damage was observed in only 16 of these counties. Over one-fourth ($337,265) of the total crop losses for New Jersey were recorded in Cumberland County. Other counties where damages exceeded $100,000 were Burlington, Atlantic, and Salem.

Only 29 out of the seventy plant species that exhibited injury were involved in the assessment of crop loss. As a group, vegetables accounted for 51 percent ($598,099) of the total crop loss. Damage to

lettuce alone accounted for over one-third ($185,425) of the losses to the vegetable crop and for about 12 percent of the estimated total crop loss in New Jersey.

The photochemical pollutants were responsible for 80 percent of the plant injury recorded, with ozone contributing about 60 percent and PAN 20 percent of the total. The other pollutants involved and their percentages of plant injury are: HCl mist and chlorine gas 6 percent, ethylene 3 percent, fluoride 2 percent, sulfur dioxide 2 percent, ammonia 2 percent, particulates 2 percent, and oil, petroleum and an unidentified pollutant 3 percent.

Air pollution gardens were maintained in various areas of the state to aid the cooperators in noting time and classification of pollution damage.

## Listing of Tables and Figures

## INTRODUCTION

New Jersey, perhaps the most urbanized state in the nation, has 1,035,678 acres of farm land; 496,241 acres of which are devoted to the production of food crops. The value of these crops sold in 1969 amounted to $124,254,021 accounting for more than 50 percent of the total farm marketings (1). New Jersey ranked 36 among the states in total cash crop receipts in 1970, and is considered a major state in the production of several important crops (1, 2). The rank of New Jersey in the production of selected crops is shown in Table 1. The total acreage and dollar value of important crops grown are shown in Table 2.

Although air pollution damage to crops has been known for more than a century, the problem did not become serious in New Jersey until the late years of World War II. Prior to this time air pollution damage in the state was believed to be limited to that produced by $SO_2$, illuminating gas and ethylene (5). However, expansion in industry and vehicular traffic, and new processes in connection with the war effort introduced new pollutants which created a serious threat to our highly valuable agricultural industry.

Air Pollution injury to crops in New Jersey was first observed in two locations along the Delaware River (5). In 1946 the State Legislature appropriated funds to the New Jersey Agricultural Experiment Station to make a study on the effect of industrial fumes on adjoining agricultural lands and their effect on plant and animal life in the State of New Jersey.

A research team from Rutgers University headed by Dr. Robert H. Daines was appointed to investigate this problem. They reported that foliage injury observed in cultivated crops, ornamentals and native vegetation could not be attributed to any known disease, nor to temperature or fertilizer effects. However, the similarity of injury on corn and peaches from cryolite, a fluoride-containing insecticide, and the presence of industrial establishments in the area that were actively engaged in the production and use of fluorine, implicated fluorine as the responsible pollutant. Since then this group of researchers has published valuable papers on the identification and relative levels of some air pollutants occurring in the atmosphere of New Jersey, plant species affected, and effects of climatic, nutritional, and biological factors affecting plant response to specific air pollutants. Other works have been published which have improved our knowledge of the basic aspects of pollutant absorption, translocation and their effects on the physiological activities of plants.

The advancing urbanization of the state no doubt poses increasing problems to agricultural production. If agriculture is to remain the means of livelihood for many people in New Jersey, the problems created by air pollution must be minimized. The first step toward realization of this goal is to determine the nature and extent of air pollution problems in New Jersey. With this information in hand, the necessary research, manpower and funds could be directed toward solving our most urgent problems. Thus, a statewide survey was initiated to obtain a realistic appraisal of air pollution damage to vegetation in New Jersey. This kind

of information is also needed to make more rational decisions about environmental matters where the trade-off between the costs and benefits of these decisions are important.

Table 1. RANK OF NEW JERSEY FOR SELECTED CROPS IN 1971

| Crop | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Late Summer potato production | Washington | Wisconsin | Colorado | New Jersey | California |
| Vegetables - Fresh Market Production | | | | | |
| Asparagus | California | New Jersey | Washington | Massachusetts | |
| Sweet Corn | Florida | California | New York | Ohio | New Jersey |
| Green Peppers | California | Florida | New Jersey | Texas | North Carolina |
| Spinach | Texas | California | New Jersey | Colorado | |
| Tomatoes | California | Florida | New Jersey | S. Carolina | Texas |
| Vegetables - Processing Production | | | | | |
| Asparagus | California | Washington | Michigan | New Jersey | Illinois |
| Tomatoes | California | Ohio | Indiana | New Jersey | Pennsylvania |
| Fruit and Berry Production | | | | | |
| Peaches | California | S. Carolina | New Jersey | Georgia | Pennsylvania |
| Blueberries | Michigan | New Jersey | N. Carolina | Washington | |
| Cranberries | Massachusetts | Wisconsin | New Jersey | Washington | Oregon |
| Strawberries | California | Florida | Michigan | Louisiana | New Jersey |

Table 2.
ACREAGE AND DOLLAR VALUE OF SELECTED CROPS GROWN IN NEW JERSEY[1/]

| Crops | Value (thousand dollars) | Acres |
|---|---|---|
| Apples | 5,635 | — |
| Asparagus | 6,782 | 17,400 |
| Barley | 1,254 | 20,000 |
| Blueberries | 6,874 | 7,200 |
| Broccoli | 88 | 130 |
| Cabbage | 3,471 | 4,200 |
| Carrots | 481 | 1,000 |
| Cherries | 82,740 lb.[5/] | 51 |
| Corn (grain) | 6,396 | 80,000 |
| Cranberries | 2,773[3/] | 3,100 |
| Cucumbers, fresh market | 1,301 | 1,600 |
| Eggplant | 1,548 | 1.500 |
| Escarole | 1,647 | 1,100 |
| Forest Products | 611 | — |
| Grapes | 238 | — |
| Greenhouse & Nursery | 34,997 | — |
| Hay | 12,798 | 137,000 |
| Lettuce | 3,049 | 3,400 |
| Muskmelon | — | — |
| Oats | 292 | 7,000 |
| Onions | 1,864 | 1,800 |
| Peaches | 10,625 | — |

Table 2. (Continued)

| Crops | Value (thousand dollars) | Acres |
|---|---|---|
| Pears | 275,702 lb. [5] | 90 |
| Peppers | 3,617 | 8,100 |
| Potatoes, Irish | 6,738 | 11,000 |
| Raspberries | — | — |
| Rye | 263 | 10,000 |
| Snap beans, fresh market | 2,499 | 5,000 |
| Sorghum | 6,366 bu. [5] | 125 |
| Soybean (Beans) | 3,998 | 51,000 |
| Spinach, fresh market | 924 | 1,400 |
| Sweet Corn | 4,134 | 11,100 |
| Sweetpotatoes | 1,408 | 1,300 |
| Strawberries | 2,268 | 1,700 |
| Tomatoes | 18,135 | 20,900 |
| Wheat | 2,202 | 33,000 |
| Other Processing Veg. | 5,041 [2] | 18,720 |
| Miscellaneous fresh market vegetable | 5,062 [4] | — |

Christmas Trees - Included in forest products

Vegetables under glass

1/ Figures obtained from the office of New Jersey Crop Reporting Service, Trenton, N.J. 08625
2/ Includes snap beans, lima beans, beets, cucumbers for pickles, green peas and spinach.
3/ Value based on 1971 price.
4/ Includes greenhouse tomatoes.
5/ Production only. No value available.

## THE SURVEY

Surveys concerned with air pollution injury to vegetation and its economic impact on agriculture have been conducted for several years in California and for three years or more in Pennsylvania. At the present time, New England and New Jersey are involved in similar projects.

In 1969 Millecan (10) estimated that California growers suffered a 44.5 million dollar loss as a result of air pollution injury. This figure did not include losses to forest or ornamental plantings. Lacasse and Weidensaul (7) estimated an $11.5 million loss to Pennsylvania growers as a result of direct and indirect injury from air pollution. Figures for 1970 show a $25.6 million loss in California (11) and a $225 thousand loss in Pennsylvania.

Workers in New Jersey have long recognized the economic impact of air pollution on agriculture in this state (4,5,9). Although an extimate of crop loss due to air pollution in the amount of $832,700 to commercial crops has been reported by Stanford Research Institute (3), there has been no actual field survey undertaken in New Jersey.

The present survey was designed to assist in making an estimate of the economic losses resulting from air pollution damage to outdoor and greenhouse crops in New Jersey. This survey was financed by the Office of Research and Monitoring, Environmental Protection Agency, from April, 1971 to January, 1972, and by the New Jersey Department of Agriculture, Division of Rural Resources from February, 1972 to April, 1972. The survey was a cooperative effort between the Cooperative Extension Service and Department of Plant Biology of Rutgers-The State University. The

help of arborists, orchardists, nurserymen, florists, vegetable growers and gardeners was also solicited in reporting suspected air pollution injury to their plants. The author, a plant pathologist with three years experience on air pollution problems, was appointed survey leader to direct and coordinate the work with county agents and extension specialists to assess the crop loss.

A two-day training session to acquaint the participating county agents with the nature and effects of air pollution on vegetation was conducted. This program included slide-illustrated talks by nationally recognized air pollution experts. Printed information was distributed which served as guidelines for the evaluation of air pollution injury. In addition to the two-day training program, the county agents attended short courses and seminars conducted by the Department of Plant Biology on recognition of air pollution damage to fruits, vegetables and ornamental crops.

The Department of Meteorology submitted timely warnings regarding meteorological conditions conducive to possible air pollution damage incidents. The project leader then passed the information to county agents who were on the lookout for possible air pollution episodes. Once an air pollution episode was recognized, the county agent filled out the inquiry report card, modified from the Pennsylvania 1969 report card (6) (Figure 1), and mailed it to our office or informed the project leader directly by telephone. The project leader visited the area with the county agent, identified the pollutant involved whenever possible, and brought specimens to the laboratory for further diagnosis and verification. A thorough documentation of the incident was made by direct field investigation and by consulting with the growers, with

## AIR POLLUTION INJURY REPORT

Location _____

Name of grower _____

Date of injury _____

Name of crop (species and variety) _____

Acreage damaged _____ or no. of plants damaged _____

% of total no. damaged _____

% of each plant damaged _____

---

Loss in (check one): Quality _____ Quantity _____

Estimated loss _____% or $ _____

Suspected pollutant _____Suspected source _____

Remarks _____

_____

_____

Date filed _____Reporter's name_____

COOPERATIVE EXTENSION SERVICE
U.S. DEPARTMENT OF AGRICULTURE
COLLEGE OF AGRICULTURE AND
ENVIRONMENTAL SCIENCE
RUTGERS UNIVERSITY
THE STATE UNIVERSITY OF NEW JERSEY
NEW BRUNSWICK, N.J. 08903

OFFICIAL BUSINESS

POSTAGE PAID
United States Department of Agriculture

Department of Plant Pathology
College of Agriculture and Environmental Science
Box 231
New Brunswick, N.J. 08903

Attention: Dr. Alberto Feliciano

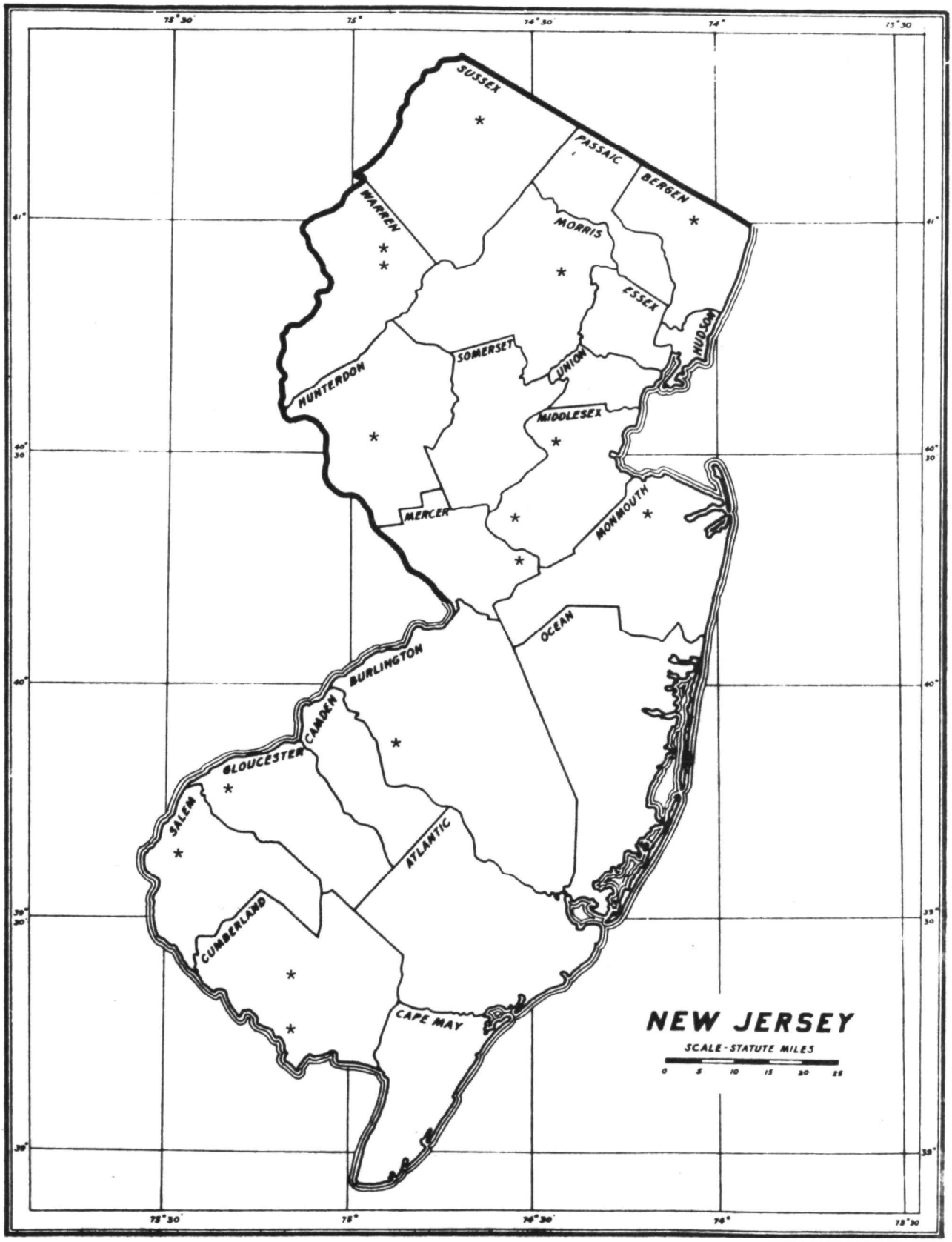
special emphasis on collection of information pertinent to assessment of crop loss. When applicable, chemical tissue analyses were conducted in the laboratory for pollutant residues. Tissue analyses were considered useful in confirming plant damage caused by fluoride, HCl mist or $Cl_2$ gas and $SO_2$. The project leader and the county agent revisited many affected fields throughout the season to provide a more accurate assessment of crop loss. Furthermore, to ensure that most of the air pollution incidences were documented, a regular appointment with each county agent was arranged in order to visit as many farms, nurseries and greenhouses as could be covered during the visit in their respective counties.

A garden containing the plants sensitive to air pollution injury was established in approximately fifteen agricultural areas throughout the state (Figure 2). The locations listed below cover the most important areas.

| | | | | | |
|---|---|---|---|---|---|
| a. | Plainsboro | f. | Salem | k. | Pinebrook |
| b. | Evesboro | g. | Swedesboro | l. | Holmdel |
| c. | Cedarville | h. | Hightstown | m. | Sussex |
| d. | Centerton | i. | Flemington | n. | New Brunswick |
| e. | Great Meadows | j. | Hackettstown | o. | Paramus |

The plant indicators used were as follows:

1. Ozone ($O_3$) - Pinto Beans and Tobacco var. Bel $W_3$
2. Sulfur Dioxide ($SO_2$) - Squash and Begonia var. Viva and Pink Tausendschon
3. Peroxyacetyl Nitrate (PAN) - Swiss Chard and Petunia var. White Sails
4. Fluoride (F) - Gladiolus var. White Friendship and Beverly Ann


75°30'
75°
74°30'
74°
73°30'
41°
40°30'
40°
39°30'
39°
SUSSEX
PASSAIC
BERGEN
WARREN
MORRIS
ESSEX
HUDSON
SOMERSET
UNION
HUNTERDON
MIDDLESEX
MERCER
MONMOUTH
OCEAN
BURLINGTON
CAMDEN
GLOUCESTER
SALEM
ATLANTIC
CUMBERLAND
CAPE MAY
NEW JERSEY
SCALE - STATUTE MILES
0 5 10 15 20 25

These "air pollution gardens," as we commonly call them, were designed to aid the cooperators in noting time, and classification of pollution damage. It also served as a valuable educational tool in maintaining the interest of cooperators.

Pinto bean and tobacco variety Bel $W_3$ were excellent indicators of ozone and PAN incidences. In one garden located in Bergen County, the agricultural county agents recorded plant injury on 8 separate dates from June 17 to September 5, 1971. Most of the plant injury was observed from 48 to 72 hours after a period of weather stagnation.

Petunia and begonia although sensitive to PAN and $SO_2$, respectively, become less susceptible to the pollutants under field conditions especially during the latter part of the growing season.

ASSESSMENT OF LOSS

Field observations provided the main source of data used in the assessment of crop loss. The number of field observations made was in turn dependent on the number of pollution incidences reported by the agricultural county agents, extension specialists, growers and other cooperators.

Methods of assessing loss as a result of air pollution varied. No specific methods could be adequately applied to all situations. In cases where the entire crop planting was rendered unmarketable, total loss was based on the crop value of the acreage affected. Data on the calculation of the harvest value of the crop and price of the commodities were obtained from the Office of New Jersey Crop Reporting Service at Trenton, New Jersey. However, when available, local crop values rather than the state averages were used in assessing crop loss. If crop damage was not complete, the loss reported reflected only that portion of the crop affected, e.g. reduction in yield or quality, increased labor cost due to removal of damaged parts, etc. In cases where no direct correlation existed between production losses and the amounts of leaf injury, a "rule of thumb" evaluation method was used for estimating loss. Where visual inspection of the overall leaf surface of the plants indicated 1 to 5 percent injury, a 1 percent loss was applied for that crop. A leaf surface injury ranging from 6 to 10 percent was given a 2 percent loss; 11 to 15 percent injury, a 4 percent loss; and 16 to 20 percent injury an 8 percent loss (11).

Assessment of loss resulting from destruction of aesthetic value, grower relocation cost, farm abandonment and other indirect effects as a result of air pollution injury was not made. Many incidences of photochemical injury to our forest and shade trees and to other crops, specifically eggplant and corn, during this 1971 survey were investigated. The lack of a suitable assessment procedure precluded any attempt to place a loss assessment in these instances. Furthermore, reduction in yield and/or quality of the crop resulting from "hidden injury" due to air pollution is not within the scope of this survey.

RESULTS

Economic Losses. The results of the survey were based primarily upon actual field observations made by the survey leader in cooperation with the farmers and the agricultural county agents from April 1971 to April 1972. The survey leader analyzed and interpreted the data and assumed responsibility for the interpretations contained within this report.

During this survey, which is in its first year, economic losses to crops in New Jersey due to air pollution amounted to $1,183,800 (Table 3). This amount represents only direct losses. Indirect losses such as grower's relocation cost, crop substitution losses, loss in value of the land, etc., were not included.

The 315 reports of air pollution damage were confirmed during the period of the survey (Table 7). Three hundred and one incidences were attributed to 8 pollutants: ozone, PAN, (peroxyacetyl nitrate), HCl mist and $Cl_2$ gas, ethylene, sulfur dioxide, ammonia, fluoride and particulates. The other 14 incidences were attributed to petroleum oil and herbicide injuries, and to an unidentified pollutant. Analysis of the data (Table 7) showed that 80 percent of the damage was caused by pollutants resulting from photochemical reactions, with ozone contributing 57 percent and PAN 23 percent of this total. Hydrochloric acid mist and chlorine gas injury, which resulted from accidental spillage from a nearby source accounted for 6 percent of the damage. Ethylene plant injury (3 percent) was essentially associated with indoor crops grown in heated glasshouses. Plant injury from fluoride (2 percent) was very localized, occurring most frequently in areas near glass factories.

Sulfur dioxide, responsible for 2 percent of the total damage was observed most frequently near industrial establishments. Accidental spillage of ammonia fron an ice plant that affected a variety of crops in the neighborhood accounted for 2 percent of the total injury attributed to air pollutants. Acid aerosols (particulates) settling on leaves, which caused small necrotic spots on the upper leaf surface, was responsible for 2 percent of the damage. Oil, petroleum and an unidentified pollutant accounted for 3 percent of the damage.

Economic loss to crops due to air pollution injury was observed in 16 counties, with Cumberland experiencing the heaviest loss ($337,265), followed by Burlington, Atlantic and Salem Counties, each with more than $100,000 loss (Table 3). The 16 counties listed in Table 3 represent the most important agricultural areas of the state.

Seventy plant species (Table 4) were observed to be affected by air pollutants during this period of the survey. Twenty-nine of these plant species were involved in the assessment of crop loss.

As a group, vegetables experienced the greatest damage with an assessed loss of $588,053. This figure represents about 51 percent of the total damage (Table 5). Damage to field crops was estimated to be $430,212. Nursery and cut-flower growers incurred a loss of $88,400. Grape, the only fruit crop represented in this survey accounted for a $67,089 loss due to air pollution. Lettuce (Iceberg, Boston and Romaine) sustained the greatest loss of any one commodity which amounted to $184, 425 for early fall and late spring crops.

Table 3.

SUMMARY OF COUNTIES SHOWING CROP LOSSES
DUE TO AIR POLLUTION, IN 1971

| | | |
|---|---|---|
| Cumberland | | 337,265 |
| Burlington | | 150,764 |
| Atlantic | | 122,439 |
| Salem | | 122,280 |
| Mercer | | 87,956 |
| Monmouth | | 84,860 |
| Gloucester | | 82,110 |
| Middlesex | | 60,053 |
| Bergen | | 50,400 |
| Cape May | | 33,779 |
| Warren | | 33,777 |
| Morris | | 8,247 |
| Camden | | 4,295 |
| Somerset | | 3,760 |
| Hunterdon | | 1,720 |
| Ocean | | 95 |
| | TOTAL | $ 1,183.800 |

Table 4.

LIST OF PLANTS AFFECTED BY AIR POLLUTANTS DURING THIS SURVEY

| Plant | Pollutant |
|---|---|
| Alfalfa<br>*Medicago sativa* L. | $O_3$ |
| Apple<br>*Malus* sp. | $NH_3$ |
| Ash, white<br>*Fraxinus americana* L. | $Cl_2$ |
| Azalea<br>*Rhododendron* sp. | Herbicide |
| Bean<br>*Phaseolus vulgaris* L | $O_3$, PAN, Herbicide |
| Bean, lima<br>*Phaeolus limensis* Macf. | $O_3$, Petroleum |
| Beet<br>*Beta vulgaris* L. | Herbicide |
| Begonia<br>*Begonia* spp. | $SO_2$ |
| Cabbage<br>*Brassica oleracea* L. | Particulate |
| Catalpa<br>*Catalpa* sp. | Particulate |
| Catbriar<br>*Smilax* sp. | $Cl_2$ |
| Celery<br>*Apium graveolens* L. | $O_3$, PAN |
| Chard, swiss<br>*Beta vulgaris* var. *cicla* L | PAN, Particulate |
| Cherry<br>*Prunus avium* L | $NH_3$ |
| Chrysanthemum<br>*Chrysanthemum* sp. | Herbicide |
| Clover<br>*Trifolium* spp | $O_3$ |
| Corn<br>*Zea mays* L. | $O_3$, Particulate |
| Cucumber<br>*Cucumis sativus* | $O_3$ |
| Cyclamen<br>*Cyclamen* Sp. | $O_3$ |
| Dandelion<br>*Taraxacum officinale* Weber | PAN |
| Dogwood<br>*Cornus florida* L. | $Cl_2$ |
| Eggplant<br>*Solanum melongena* L. | PAN |
| Elm<br>*Ulmus americana* L. | $Cl_2$ |
| Endive<br>*Chichorium endivia* L. | $O_3$, PAN, HCl |
| Fir, Douglas<br>*Pseudotsuga taxifolia* Bridt. | $Cl_2$ |
| Gladiolus<br>*Gladiolus* sp. | F |
| Gooseberry<br>*Ribes* sp | Herbicide |
| Gourd<br>*Luffa acutangula* L. | $O_3$ |
| Grape<br>*Vitis vinifera* L. | $O_3$, $NH_3$, Herbicide |

Table 4. (Continued)

| Plant | Pollutant |
|---|---|
| Hazelnut<br>*Corylus americana* Walt. | $Cl_2$ |
| Horsechestnut<br>*Aesculus* sp. | $NH_3$ |
| Iris<br>*Iris* sp. | $Cl_2$, Herbicide |
| Ivy, English<br>*Hedera helix* L. | $Cl_2$ |
| Kohlrabi<br>*Brassica caulorapa* Pasq. | Herbicide |
| Lamb's Quarter<br>*Chenopodium album* L. | $O_3$ |
| Leek<br>*Allium porrum* L. | $O_3$ |
| Lettuce<br>*Lactuca spp.* | PAN, $O_3$, Herbicide, Oil |
| Lilac<br>*Syringa vulgaris* L. | $Cl_2$ |
| Lily,<br>*Hosta*, sp. | $Cl_2$ |
| Maple, sugar<br>*Acer saccharum* Marsh. | $Cl_2$ |
| Mulberry<br>*Morus* sp. | $Cl_2$ |
| Muskmelon<br>*Cucumis melo* L. | $O_3$ |
| Mustard<br>*Brassica* sp. | PAN |
| Oak<br>*Quercus* sp. | $Cl_2$ |
| Oat<br>*Avena sativa* L. | $O_3$ |
| Onion<br>*Allium cepa* L. | $O_3$, $NH_3$ |
| Orchid<br>*Cattleya* sp.<br>*Phalaenopsis* sp. | E<br>E |
| Pea<br>*Lathyrus spp.* | $O_3$ |
| Peach<br>*Prunus persica* Sieb & Zucc. | Particulate |
| Pear<br>*Pyrus* sp. | $NH_3$ |
| Petunia<br>*Petunia hybrida* Vilm | $O_3$, PAN |
| Pigweed<br>*Amaranthus* sp. | $O_3$ |
| Pine, Scotch<br>*Pinus sylvestris* L. | $Cl_3$ |
| Pine, white<br>*Pinus strobus* L. | $O_3$ |
| Plum<br>*Prunus* sp. | $NH_3$ |
| Potato<br>*Solanum tuberosum* L. | PAN, $O_3$ |
| Pumpkin<br>*Cucurbita pepo* L. | $O_3$ |
| Radish<br>*Rhapanus sativus* L. | $O_3$, PAN |

Table 4. (continued)

| Plant | Pollutant |
|---|---|
| Rose<br>*Rosa* spp | Herbicide |
| Sorrel<br>*Rumex acetosa* L. | PAN |
| Soybean<br>*Glycine max* Merr | $O_3$ |
| Spinach<br>*Spinacia oleracea* L. | $O_3$ |
| Squash<br>*Cucurbita* spp. | $O_3$ |
| Sunflower, Common<br>*Helianthus annuus* L. | $O_3$ |
| Sycamore<br>*Platanus* sp. | $O_3$ |
| Tomato<br>*Lycopersicon esculentum* Mill | $O_3$, PAN, $NH_3$, Herbicide |
| Tulip, Darwin<br>*Tulipa gesneriana* var. *darwinia* Bailey | $SO_2$ |
| Tulip tree<br>*Liriodendron tulipifera* | $Cl_2$ |
| Turnip<br>*Brassica rapa* L. | PAN |
| Watermelon<br>*Citrullus vulgaris* Schrad. | $O_3$ |

Table 4. (Continued)

| Plant | Pollutant |
|---|---|
| Soybean<br>*Glycine mas* Merr. | $O_3$ |
| Spinach<br>*Spinacia oleracea* L. | $O_3$ |
| Squash<br>*Cucurbita* spp. | $O_3$ |
| Sunflower, Common<br>*Helianthus annuus* L. | $O_3$ |
| Sycamore<br>*Platanus* sp. | $O_3$ |
| Tomato<br>*Lycopersicon esculentum* Mill | $O_3$, PAN, $NH_3$, Herbicide |
| Tulip, Darwin<br>*Tulipa gesneriana* var. *darwinia* Bailey | $SO_2$ |
| Tulip tree<br>*Liriodendron tulopifera* | $Cl_2$ |
| Turnip<br>*Brassica rapa* L. | PAN |
| Watermelon<br>*Citrullus vulgaris* Schrad. | $O_3$ |

## DISCUSSION AND RECOMMENDATIONS

The state of New Jersey has a total of 21 counties (Figure 2), however, data from only 16 counties were involved in the assessment of crop losses due to air pollution. The absence of air pollution damage to crops in the four remaining counties—Sussex, Essex, Hudson and Union—does not imply that these counties are "pollution-free," but rather, incidences in these areas were either not serious enough to realize economic loss or were simply overlooked and not reported at all. The survey was concentrated in the central and southern counties where most of the important agricultural crops such as fruits and vegetables are grown.

The cooperation of agricultural county agents and farmers made this initial survey possible. The county agents travel constantly in rural areas and growers call upon them for any problems that arise. County agents are extremely busy, however, especially during the growing season and would have little time to look specifically for air pollution damage. Most of the reported air pollution cases are brought to the attention of the county agents by the growers. Minor injuries, causing no noticeable damage to the plants would therefore easily go undetected.

This serious drawback was realized during the first few months of the survey. To alleviate this problem the project leader arranged for regular visits with each county agent to inspect as many farms, orchards, nurseries and greenhouses in his county as possible. This approach kept us in constant association with the farmers and enabled us to get firsthand knowledge of crop development. This procedure also gave me the opportunity

to demonstrate and explain to county agents and growers what air pollution injury looks like and how it affects their crops. Air pollution gardens were most helpful in this respect.

As a result of this approach many air pollution injuries to crops were observed and documented which would otherwise have gone unnoticed and not reported. These regular visits however were only possible because of the size of New Jersey. Since the success of the project depends on recognition of the injury by the farmers or the county agents, a continuing program aimed at educating the people concerned through demonstration and conferences should be pursued as often as possible.

The establishment of "air pollution gardens" will be continued during the 1972 survey. However, gardens will be limited to counties that expressed interest in maintaining them. Maintenance of the gardens posed a problem to the already overloaded schedule of the cooperators, and therefore, their establishment will not be imposed. In addition to the outdoor gardens, plant indicators will be established in greenhouses this year.

During the survey, instances of air pollution injury to landscape plantings and native vegetation were likewise noted but no attempt was made to tag a dollar value to this type of injury. There was also no basis for judging any small degree of reduced growth and reproduction (damage without visual symptoms of injury) due to air pollutants, which undoubtedly occurred. More research work is necessary to explore the relationship between air pollutants and growth suppression before any meaningful correlation can be made. Furthermore, there is an acute awareness that

photochemical pollutants (specifically ozone and PAN) account for the greater portion of the damage to crops in New Jersey. Whereas monitoring for ozone is a continuing practice, our knowledge of PAN formation and accumulation in the atmosphere of New Jersey is practically nil.

In many instances an unidentified pollutant causing foliar injury on Irish potato and tomato has been observed. The symptoms appear as numerous spots on the lower surface of the leaves with a characteristic bronze color. The symptoms were first observed two to three days after a period of weather stagnation. In one instance, tomato plantings (variety Supersonic and Jetstar) were injured at flowering. The flowers dropped off and the upper stems became woody prematurely resulting in a 40 percent reduction in yield. The importance of research along these lines can not be overemphasized.

Greenhouse problems were mainly due to faulty burners that failed to burn fuel properly, improper ventilation and use of poor grades of fuel. Timely diagnosis and appropriate actions for control often minimized crop losses in cases where the damage was not too severe.

Table 5.

SUMMARY OF 1971 CROP LOSSES IN NEW JERSEY
DUE TO AIR POLLUTION

| Crop | Acreage Affected<br>acres | Harvest Value*** | Amount of Loss<br>dollars |
|---|---|---|---|
| FIELD | | | |
| Alfalfa | 12,590 | ** | 111,882 |
| Clover | 10,305 | ** | 86,49[illegible] |
| Potato | 1,725 | 1,210,950 | 86,004 |
| Soybean | 22,509 | 1,553,121 | 145,827 |
| | 47,129 | 2,764,071 | 430,212 |
| FRUIT | | | |
| Grape | 264 | 229,337 | 67,089 |
| NURSERY AND CUT FLOWERS | | | |
| Gladiolus | 383 | 1,916,532 | 36,540 |
| Ivy | 6,000* | ** | 1,360 |
| Orchid | 80,000* | ** | 50,000 |
| Miscellaneous | 1 | ** | 500 |
| | 383<br>86,000* | 1,916,532 | 88,400 |
| VEGETABLE | | | |
| Bean, bush, pole, snap | 4,158 | 1,975,050 | 71,105 |
| Bean, Lima | 4,136 | 827,200 | 74,754 |
| Cabbage | 1 | 878 | 311 |
| Chard | 21 | 15,792 | 1,322 |
| Cucumber | 2,035 | 1,843,710 | 36,890 |

Table 5. (Continued)

| Crop | Acreage Affected (acres) | Harvest Value*** (dollars) | Amount of Loss (dollars) |
|---|---|---|---|
| Vegetable (Continued) | | | |
| Dandelion | 9 | 14,328 | 4,629 |
| Endive and Escarole | 427 | 565,775 | 52,146 |
| Gourd | 7 | ** | 650 |
| Leek and Green Onion | 151 | ** | 8,138 |
| Lettuce | 618 | 500,142 | 185,425 |
| Muskmelon | 375 | 366,375 | 3,252 |
| Mustard | 13 | 7,800 | 905 |
| Onion, Dry | 1,800 | 1,668,600 | 9,353 |
| Pumpkin | 531 | 531,000 | 5,616 |
| Spinach | 20 | 11,600 | 76 |
| Sorrel | 2 | 2,000 | 300 |
| Squash | 103 | 93,524 | 2,365 |
| Tomato | | | |
| Fresh Market | 672 | 667,270 | 64,255 |
| Processing | 1,993 | 1,600,379 | 67,427 |
| Tomato | 24,480* | ** | 7,830 |
| Watermelon | 254 | 36,322 | 850 |
| Miscellaneous | 1,125* | | 200 |
| | 17,326<br>25,605* | 10,727,745 | 598,099 |
| TOTALS | 65,102<br>111,605* | 15,637,685 | 1,183,754 |

* Greenhouse in square feet
** Harvest value not available
*** New Jersey Crop Reporting Service

Table 6.

COUNTY CROP LOSSES

| County and Crop | Acreage Affected | Harvest Value | Amount of Loss |
|---|---|---|---|
| | acres | dollars | |
| ATLANTIC | | | |
| Field | | | |
| Potato | 200 | 140,400 | 17,896 |
| Fruit | | | |
| Grape | 191 | 165,462 | 53,404 |
| Vegetable | | | |
| Beans, bush, pole, snap | 156 | 74,100 | 2,388 |
| Cucumber | 403 | 365,118 | 7,302 |
| Endive and Escarole | 50 | 66,250 | 4,00 |
| Leek and Green Onion | 39 | ** | 2,148 |
| Lettuce | 51 | 40,287 | 18,197 |
| Muskmelon | 53 | 51,781 | 460 |
| Pumpkin | 21 | 21,000 | 214 |
| Tomato | | | |
| Fresh market | 205 | 195,365 | 10,907 |
| Processing | 293 | 235,279 | 5,353 |
| Watermelon | 49 | 7,007 | 170 |
| TOTALS | 1,711 | 1,362,049 | 122,439 |
| BERGEN | | | |
| Nursery and Cutflowers | | | |
| Orchids | 80,000* | ** | 50,000 |
| Tulip | 0.2 | ** | 400 |
| TOTALS | | | 50,400 |

Table 6. (Continued)

| County and Crop | Acreage Affected | Harvest Value | Amount of Loss |
|---|---|---|---|
| | acres | dollars | |
| BURLINGTON | | | |
| Field | | | |
| Alfalfa | 5,000 | ** | 62,000 |
| Clover | 3,000 | ** | 37,200 |
| Soybean | 3,056 | 210,864 | 21,392 |
| Fruit | | | |
| Grape | 42 | 36,750 | 6,615 |
| Vegetable | | | |
| Beans, bush, pole, snap | 360 | 171,000 | 18,204 |
| Pumpkin | 16 | 16,000 | 163 |
| Tomato | 12,930* | ** | 5,050 |
| Watermelon | 28 | 4,004 | 140 |
| TOTALS | 11,502 | 438,618 | 150,764 |
| CAMDEN | | | |
| Fruit | 18 | | |
| Grape | | 15,750 | 4,295 |
| CAPE MAY | | | |
| Vegetable | | | |
| Beans, bush, pole, snap | 50 | 23,750 | 1,445 |
| Beans, lima | 1,965 | 393,000 | 32,334 |
| TOTAL | 2,015 | 416,750 | 33,779 |

Table 6. (Continued)

| County and Crop | Acreage Affected (Acres) | Harvest Value (dollars) | Amount of Loss (dollars) |
|---|---|---|---|
| CUMBERLAND | | | |
| Field | | | |
| Potato | 572 | 401,544 | 42,038 |
| Soybean | 1,065 | 73,485 | 12,455 |
| Nursery and Cut Flowers | | | |
| Gladiolus | 256 | 1,281,024 | 24,390 |
| Vegetable | | | |
| Bean, bush, pole, snap | 2,305 | 1,094,875 | 20,514 |
| Bean, lima | 1,524 | 304,800 | 28,480 |
| Chard | 5 | 3,760 | 250 |
| Cucumber | 800 | 724,800 | 14,496 |
| Dandelion | 3 | 4,776 | 148 |
| Endive and Escarole | 100 | 132,500 | 4,000 |
| Leek and Green Onion | 112 | ** | 5,990 |
| Lettuce, Romaine and Iceberg (late spring and early fall) | 530 | 420,820 | 146,205 |
| Lettuce, Romaine | 1,125* | ** | 200 |
| Muskmelon | 123 | 120,171 | 1,065 |
| Mustard | 10 | 6,000 | 410 |
| Onion, Dry | 1,350 | 1,251,450 | 4,561 |
| Sorrel | 2 | 2,000 | 300 |
| Tomato | | | |
| Fresh Market | 53 | 50,509 | 15,573 |
| Processing | 347 | 278,641 | 15,645 |
| Tomato | 2,700 | ** | 405 |
| Watermelon | 109 | 15,587 | 140 |
| TOTAL | 9,266 | 6,166,742 | 337,265 |

Table 6. (Continued)

| County and Crop | Acreage Affected | Harvest Value | Amount of Loss |
|---|---|---|---|
| | acres | dollars | |
| GLOUCESTER | | | |
| Field | | | |
| Soybean | 709 | 48,921 | 4,963 |
| Nursery and Cut Flowers | | | |
| Gladiolus | 127 | 635,508 | 12,150 |
| Vegetable | | | |
| Beans, bush, pole, snap | 110 | 52,250 | 1,979 |
| Chard | 1 | 752 | 70 |
| Cucumber | 305 | 276,330 | 5,527 |
| Lettuce | 10 | 10,010 | 5,870 |
| Muskmelon | 30 | 29,310 | 260 |
| Onion, Dry | 250 | 231,750 | 1,965 |
| Pumpkin | 300 | 300,000 | 3,060 |
| Tomato | | | |
| Fresh Market | 246 | 234,438 | 14,689 |
| Processing | 1,108 | 889,724 | 30,527 |
| Tomato | 2,250* | ** | 1,050 |
| TOTAL | 3,196 | 2,708,993 | 82,110 |
| HUNTERDON | | | |
| Field | | | |
| Soybean | 40 | 2,760 | 1,720 |
| MERCER | | | |
| Field | | | |
| Alfalfa | 890 | ** | 12,497 |
| Clover | 2,000 | ** | 23,600 |
| Soybean | 5,765 | 397,785 | 40,355 |

Table 6. (Continued)

| County and Crop | Acreage Affected | Harvest Value | Amount of Loss |
|---|---|---|---|
| | acres | dollars | |
| (Mercer Continued) | | | |
| Vegetable | | | |
| Tomato | 2 | 28,760 | 11,504 |
| TOTAL | 8,657 | 426, 545 | 87,956 |
| MIDDLESEX | | | |
| Field | | | |
| Alfalfa | 500 | ** | 13,800 |
| Clover | 700 | ** | 3,260 |
| Potato | 300 | 210,600 | 7,390 |
| Soybean | 2,158 | 148,902 | 23,306 |
| Vegetable | | | |
| Bean, bush, pole, snap | 27 | 12,825 | 340 |
| Bean, Lima | 40 | 8,000 | 1,800 |
| Chard | 10 | 7,520 | 282 |
| Cucumber | 4 | 3,624 | 72 |
| Endive and Escarole | 10 | 13,250 | 400 |
| Dandelion | 6 | 9,552 | 4,481 |
| Lettuce | 4 | 4,004 | 2,348 |
| Mustard | 3 | 1,800 | 495 |
| Pumpkin | 14 | 14,000 | 243 |
| Spinach | 20 | 11,600 | 76 |
| Nursery and Cut Flowers | | | |
| Ivy | 6,000* | ** | 1,360 |
| Roses | 0.3 | ** | 100 |
| TOTAL | 3,796 | 445,677 | 60,053 |

Table 6. (Continued)

| County and Crop | Acreage Affected | Harvest Value | Amount of Loss |
|---|---|---|---|
| | acres | dollars | |
| MONMOUTH | | | |
| Field | | | |
| Alfalfa | 2,000 | ** | 12,600 |
| Clover | 1,500 | ** | 6,700 |
| Potato | 630 | 442,260 | 15,545 |
| Soybean | 7,246 | 499,974 | 24,346 |
| Fruit | | | |
| Grape | 13 | 11,375 | 2,775 |
| Vegetable | | | |
| Bean, bush, pole, snap | 150 | 71,250 | 7,335 |
| Cucumber | 23 | 20,838 | 433 |
| Endive and Escarole | 64 | 84,800 | 9,200 |
| Gourd | 7 | ** | 650 |
| Lettuce | 6 | 6,006 | 3,522 |
| Pumpkin | 105 | 105,000 | 1,071 |
| Muskmelon | 47 | 45,919 | 408 |
| Watermelon | 54 | 7,722 | 275 |
| TOTAL | 11,845 | 1,295,144 | 84,860 |
| MORRIS | | | |
| Vegetable | | | |
| Endive and Escarole | 50 | 66,250 | 6,700 |
| Pumpkin | 12 | 12,000 | 222 |
| Tomato | 6,600* | ** | 1,325 |
| TOTAL | 62 | 78,250 | 8,247 |

Table 6. (Continued)

| County and Crop | Acreage Affected | Harvest Value | Amount of Loss |
|---|---|---|---|
| | acres | dollars | |
| OCEAN | | | |
| Vegetables | | | |
| Tomato (fresh market) | 10 | 9,530 | 95 |
| SALEM | | | |
| Field | | | |
| Alfalfa | 3,000 | ** | 8,275 |
| Clover | 2,605 | ** | 14,689 |
| Potato | 23 | 16,146 | 3,135 |
| Soybean | 2,470 | 170,430 | 17,290 |
| Vegetable | | | |
| Bean , bush, pole, snap | 1,000 | 475,000 | 18,900 |
| Bean, Lima | 607 | 121,400 | 12,140 |
| Cucumber | 500 | 453,000 | 9,060 |
| Lettuce | 15 | 15,015 | 5,283 |
| Muskmelon | 122 | 119,194 | 1,059 |
| Onion, Dry | 100 | 92,700 | 1,927 |
| Pumpkin | 63 | 63,000 | 643 |
| Squash | 103 | 93,524 | 2,365 |
| Tomato | | | |
| Fresh Market | 156 | 148,668 | 11,487 |
| Processing | 245 | 196,735 | 15,902 |
| Watermelon | 14 | 2,002 | 125 |
| TOTAL | 11,023 | 1,966,814 | 122,280 |

Table 6. (Continued)

| County and Crop | Acreage Affected (acres) | Harvest Value (dollars) | Amount of Loss (dollars) |
|---|---|---|---|
| SOMERSET | | | |
| Field | | | |
| Alfalfa | 1,200 | ** | 2,710 |
| Clover | 500 | ** | 1,050 |
| TOTAL | 1,700 | | 3,760 |
| WARREN | | | |
| Vegetable | | | |
| Cabbage | 1 | 878 | 311 |
| Chard | 5 | 3,760 | 720 |
| Endive and Escarole | 153 | 202,725 | 27,846 |
| Lettuce | 4 | 4,000 | 4,000 |
| Onion, Dry | 100 | 92,700 | 900 |
| TOTAL | 261 | 304,063 | 33,777 |
| GRAND TOTAL | 65,102 | 15,637,685 | 1,183,754 |

* Greenhouse in square feet.
** Harvest value not available.

Table 7.

SUMMARY OF PLANT INJURY REPORT BY COUNTIES

| County and Crop | Pollutant[1/] | Number of Reports |
|---|---|---|
| ATLANTIC | | |
| Field | | |
| Potato | $O_3$ | 2 |
| | PAN | 1 |
| Fruit | | |
| Grape | $O_3$ | 2 |
| Vegetable | | |
| Bean | $O_3$ | 1 |
| Cucumber | $O_3$ | 3 |
| Endive and Escarole | Pan | 2 |
| | $O_3$ | 1 |
| Leek and Green Onion | $O_3$ | 2 |
| Lettuce | Pan | 3 |
| Muskmelon | $O_3$ | 1 |
| Pumpkin | $O_3$ | 2 |
| Tomato | $O_3$ | 3 |
| | Pan | 2 |
| Watermelon | $O_3$ | 1 |
| | | 26 |
| BERGEN | | |
| Floral and Weed Crop | | |
| Catbriar | $Cl_2$ | 1 |
| Dogwood | $Cl_2$ | 1 |
| Iris | $Cl_2$ | 1 |
| Lily | $Cl_2$ | 1 |
| Lilac | $Cl_2$ | 1 |

Table 7. (Continued)

| County and Crop | Pollutant[1] | Number of Reports |
|---|---|---|
| Bergen (Continued) | | |
| Petunia | PAN | 1 |
| Orchid | E | 7 |
| Tulip | $SO_2$ | 1 |
| Forest and Shade Trees | | |
| Ash | $Cl_2$ | 1 |
| Elm | $Cl_2$ | 1 |
| Fir | $Cl_2$ | 1 |
| Hazel nut | $Cl_2$ | 1 |
| Maple | $Cl_2$ | 1 |
| Mulberry | $Cl_2$ | 1 |
| Oak | $Cl_2$ | 1 |
| Pine | $Cl_2$ | 1 |
| Tuliptree | $Cl_2$ | 1 |
| | | 23 |
| BURLINGTON | | |
| Field | | |
| Alfalfa | $O_3$ | 4 |
| Clover | $O_3$ | 4 |
| Soybean | $O_3$ | 3 |
| Fruit | | |
| Grape | $O_3$ | 1 |
| Vegetables | | |
| Beans | $O_3$ | 2 |
| Pumpkin | $O_3$ | 2 |
| Tomato | $O_3$ | 1 |
| | $SO_2$ | 2 |
| Watermelon | $O_3$ | 1 |
| | | 20 |

Table 7. (Continued)

| County and Crop | Pollutant [1/] | Number of Reports |
|---|---|---|
| CAMDEN | | |
| Fruit | | |
| Grape | $O_3$ | 1 |
| CAPE MAY | | |
| Vegetable | | |
| Beans | $O_3$ | 5 |
| | Pet | 1 |
| | | 6 |
| CUMBERLAND | | |
| Field | | |
| Potato | $O_3$ | 3 |
| | PAN | 4 |
| Soybean | $O_3$ | 2 |
| Vegetable | | |
| Bean | $O_3$ | 3 |
| Chard | PAN | 1 |
| Cucumber | $O_3$ | 2 |
| Dandelion | PAN | 1 |
| Eggplant | PAN | 5 |
| Endive and Escarole | PAN | 1 |
| Leek and Green Onion | $O_3$ | 3 |
| Lettuce | PAN | 2 |
| | $O_3$ | 2 |
| | Oil | 1 |
| Muskmelon | $O_3$ | 1 |
| Mustard | PAN | 1 |
| Onion, Dry | $O_3$ | 2 |
| Radish | $O_3$ | 1 |
| Sorrel | PAN | 2 |
| Tomato | $O_3$ | 5 |
| | PAN | 3 |
| | $SO_2$ | 2 |

Table 7. (Continued)

| County and Crop | Pollutant [1/] | Number of Reports |
|---|---|---|
| Cumberland (Continued) | | |
| Vegetables | | |
| Turnip | PAN | 1 |
| Watermelon | $O_3$ | 1 |
| Nursery and Cut Flowers | | |
| Gladiolus | F | 2 |
| | | 51 |
| GLOUCESTER | | |
| Field | | |
| Soybean | $O_3$ | 4 |
| Nursery and Cut Flowers | | |
| Gladiolus | F | 3 |
| Vegetable | | |
| Bean | $O_3$ | 2 |
| Chard | PAN | 1 |
| Cucumber | $O_3$ | 3 |
| Lettuce | PAN | 1 |
| Muskmelon | $O_3$ | 1 |
| Pumpkin | $O_3$ | 1 |
| Tomato | $O_3$ | 2 |
| | PAN | 2 |
| | | 20 |
| HUNTERDON | | |
| Field | | |
| Soybean | H | 1 |
| MERCER | | |
| Field | | |
| Alfalfa | $O_3$ | 2 |
| Clover | $O_3$ | 2 |
| Soybean | $O_3$ | 3 |
| | PAN | 1 |
| Vegetable | | |
| Tomato | PAN | 1 |
| | U | 1 |
| | 38 | 10 |

Table 7. (Continued)

| County and Crop | Pollutant | Number of Reports |
|---|---|---|
| MIDDLESEX | | |
| Field | | |
| Alfalfa | $O_3$ | 3 |
| Clover | $O_3$ | 3 |
| Oat | $O_3$ | 1 |
| Potato | PAN | 1 |
| | $O_3$ | 1 |
| Soybean | $O_3$ | 3 |
| Floral and Weed Crop | | |
| Azalea | H | 1 |
| Begonia | $SO_2$ | 2 |
| Chrysanthemum | H | 1 |
| Iris | H | 1 |
| Ivy | Cl | 1 |
| Lamb's Quarter | $O_3$ | 2 |
| Petunia | $O_3$ | 3 |
| Pigweed | $O_3$ | 1 |
| Rose | H | 1 |
| Sunflower | $O_3$ | 1 |
| Sycamore | $O_3$ | 2 |
| Forest and Shade | | |
| Pine | $O_3$ | 2 |
| Chestnut | $NH_3$ | 1 |
| Fruit | | |
| Apple | $NH_3$ | 1 |
| Cherry | $NH_3$ | 1 |
| Gooseberry | H | 1 |
| Grape | $NH_3$ | 1 |
| | H | 1 |
| Pear | $NH_3$ | 1 |
| Plum | $NH_3$ | 1 |

Table 7. (Continued)

| County and Crop | Pollutant[1/] | Number of Reports |
|---|---|---|
| Middlesex (continued) | | |
| Vegetable | | |
| Bean | H | 1 |
| | $O_3$ | 1 |
| Beet | H | 1 |
| Chard | P | 1 |
| | PAN | 1 |
| Cucumber | $O_3$ | 1 |
| Endive and Escarole | PAN | 2 |
| Dandelion | PAN | 1 |
| Kohlrabi | H | 1 |
| Lettuce | H | 1 |
| | PAN | 2 |
| Mustard | PAN | 1 |
| Pumpkin | $O_3$ | 1 |
| Spinach | $O_3$ | 2 |
| | | 55 |
| MONMOUTH | | |
| Field | | |
| Alfalfa | $O_3$ | 2 |
| Clover | $O_3$ | 1 |
| Potato | $O_3$ | 1 |
| | PAN | 3 |
| Soybean | $O_3$ | 4 |
| Fruit | | |
| Grape | $O_3$ | 1 |
| Vegetable | | |
| Bean | $O_3$ | 2 |
| Cucumber | $O_3$ | 2 |
| Endive and Escarole | PAN | 3 |
| Gourd | $O_3$ | 1 |
| Lettuce | PAN | 2 |

Table 7. (Continued)

| County and Crop | Pollutant[1] | Number of Reports |
|---|---|---|
| Monmouth (continued) | | |
| Vegetable | | |
| Pumpkin | $O_3$ | 3 |
| Muskmelon | $O_3$ | 2 |
| Watermelon | $O_3$ | 1 |
| | | 28 |
| MORRIS | | |
| Vegetables | | |
| Endive and Escarole | PAN | 2 |
| Pumpkin | $O_3$ | 1 |
| Tomato | E | 1 |
| Floral and Weed Crop | | |
| Cyclamen | $O_3$ | 1 |
| | | 5 |
| OCEAN | | |
| Vegetable | | |
| Tomato | PAN | 1 |
| PASSAIC | | |
| Field | | |
| Corn | P | 1 |
| Fruit | | |
| Peach | P | 1 |
| Forest and Shade | | |
| Catalpa | P | 1 |
| | | 3 |
| SALEM | | |
| Field | | |
| Alfalfa | $O_3$ | 2 |
| Clover | $O_3$ | 3 |
| Potato | PAN | 1 |
| | $O_3$ | 2 |
| Soybean | $O_3$ | 3 |

Table 7. (Continued)

| County and Crop | Pollutant [1/] | Number of Reports |
|---|---|---|
| Salem (continued) | | |
| Vegetable | | |
| Bean | PAN | 3 |
| | $O_3$ | 4 |
| Celery | PAN | 1 |
| | $O_3$ | 1 |
| Cucumber | $O_3$ | 3 |
| Lettuce | PAN | 2 |
| Muskmelon | $O_3$ | 4 |
| Onion, Dry | $O_3$ | 2 |
| Pumpkin | $O_3$ | 3 |
| Squash | $O_3$ | 4 |
| Tomato | PAN | 4 |
| | $O_3$ | 2 |
| Watermelon | $O_3$ | 1 |
| | | 45 |
| SOMERSET | | |
| Field | | |
| Alfalfa | $O_3$ | 2 |
| Clover | $O_3$ | 2 |
| | | 4 |
| WARREN | | |
| Vegetable | | |
| Cabbage | P | 1 |
| Chard | PAN | 1 |
| Endive and Escarole | PAN | 4 |
| | HCl | 3 |
| | $O_3$ | 2 |
| Lettuce | PAN | 3 |
| Onion, Dry | $O_3$ | 2 |
| | | 16 |
| | GRAND TOTAL | 315 |

1/ $Cl_2$ = Chlorine gas
E = Ethylene
F = Fluoride
H = Herbicide
$NH_3$ = Ammonia
$O_3$ = Ozone
PAN = Peroxyacetyl nitrate
P = Particulate
Pet = Petroleum
$SO_2$ = Sulfur Dioxide
U = Unidentified pollutant

LITERATURE CITED


1. 1969 Census of Agriculture. Volume 1. Part 8. New Jersey.

2. 1970 New Jersey Agricultural Statistics. N.J. Crop Reporting Service. Circular 458. N.J. Dept. of Agriculture, Trenton, New Jersey.

3. Benedict, H.M. and R. E. Olson. 1970. Economic impact of air pollutants on plants. Volume 1. Stanford Research Institute. SRI-Irvine, California.

4. Daines, R.H., E. Brennan and I.A. Leone. 1960. Air pollution headache grows now covering large urban areas. Florists' Exchange 135: 18-22.

5. Daines, R.H., E. Brennan and I.A. Leone. 1960. Air pollution as it affects agriculture in New Jersey. N.J. Agric. Expt. Sta. Bulletin No. 794.

6. Lacasse, N.L. and W.J. Moroz. 1969. Handbook of Effects Assessment. Vegetation Damage. Center for Air Environment Studies, The Pennsylvania State University, Univ. Park, Pa.

7. Lacasse, N.L. and T. C. Weidensaul. 1970. A cooperative extension-based system of assessing air pollution damage to vegetation: organization, results and recommendations for future surveys. Center for Air Environment Studies. The Pennsylvania State Univ.

8. Lacasse, N.L. 1971. Assessment of air pollution damage to vegetation in Pennsylvania. Center for Air Environment Studies. The Pennsylvania State Univ.

9. Leone, I.A., E. Brennan and R. H. Daines. 1963. Air pollution new threat to farmers. New Jersey Business 34: 17-20.

10. Millecan, A.A. 1970. Air pollution crop losses in 1969. Unpublished.

11. Millecan, A.A. 1971. A survey and assessment of air pollution damage to California vegetation in 1970. California Dept. of Agriculture, Sacramento, California.