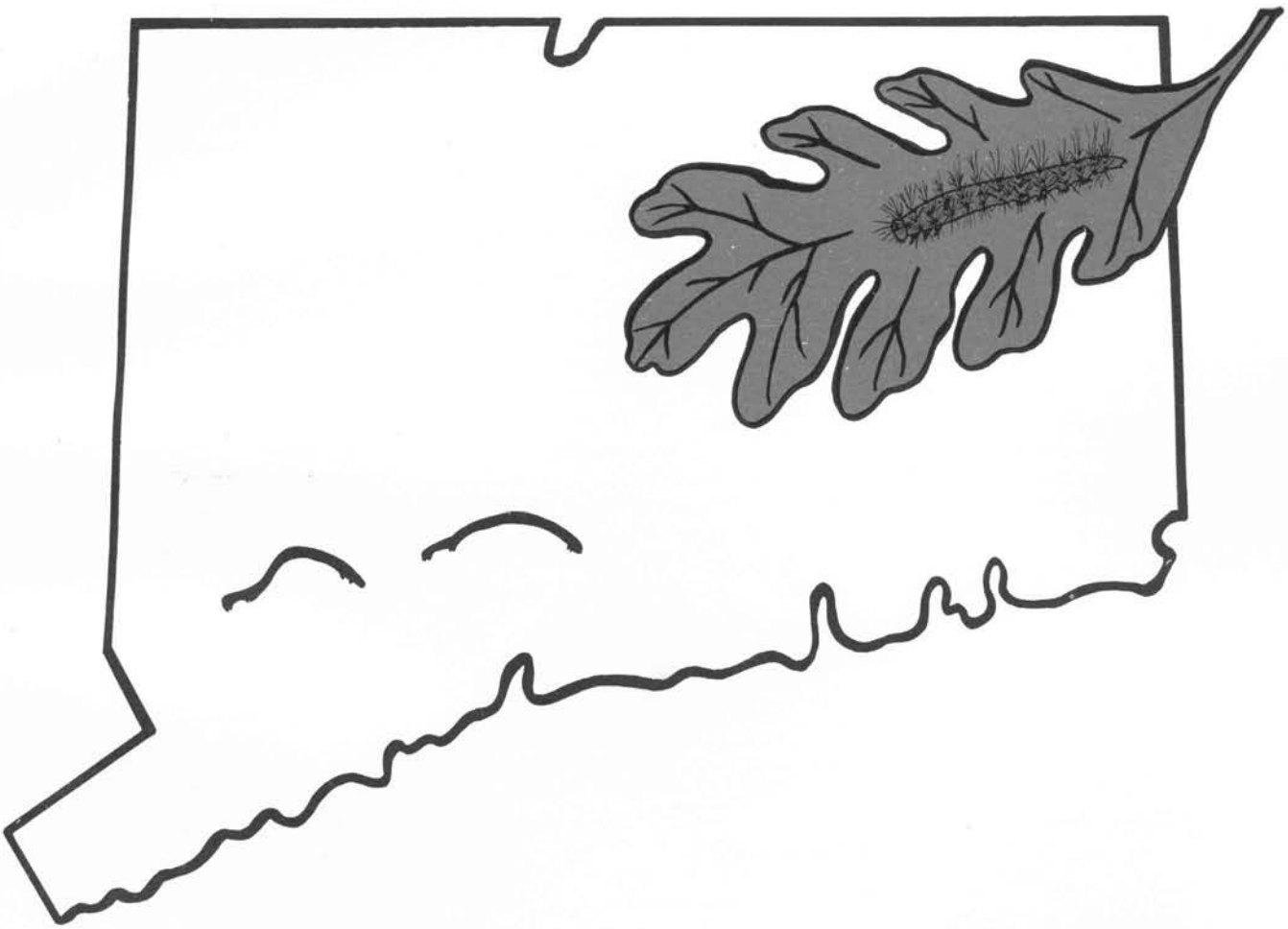
# DEFOLIATION

## In Connecticut 1969-1974

Tabulated by use of the Geo-Code



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The gypsy moth, *Porthetria dispar* (L)[1], and elm spanworm, *Ennomos subsignarius* (Hübner)[2], reached unprecedented numbers in Connecticut in the early 1970's. The elm spanworm outbreak which began in 1970 collapsed in large part in the summer of 1972. Gypsy moth outbreaks were common in Connecticut during the 1950's and the 1960's (Turner 1963a), but areas in excess of 200,000 acres were not defoliated until the early 1970's. Outbreaks continued through 1974.

Defoliation had not caused high tree mortality in Connecticut (Stephens 1971), but large numbers of trees died elsewhere (Turner 1963b, Kegg 1971.) However, Dunbar and Stephens (ms. submitted) show that a high percentage of oaks, particularly chestnut oaks, which tend to grow on ridgetops and shallow, rocky soils, have recently died in several areas of the state. The cause of death was attributed mainly to the two-lined chestnut borer, *Agrilus bilineatus* (Web.), which principally attacks trees weakened by defoliation or other causes (Chapman 1915).

Defoliation data in this bulletin may serve as a partial guide to areas where oak trees may be more susceptible to attack by the two-lined chestnut borer and where higher mortality of oak trees may be expected. But the data may also, in time, show that extensive and severe defoliation, even in successive years, may not necessarily result in extensive tree mortality in Connecticut.

The data show the location, intensity and duration of the outbreaks of both insects during 1969-74 and their pattern of dispersal. The effects on defoliation of aerial spraying with carbaryl are also discussed.

1. Lymantriidae
2. Geometriidae

**Geo-Code**

The Geo-Code system devised by Gould (1968, 1972) was used to record and tabulate defoliation. Four-letter Geo-Codes were assigned to the eight counties. Because Connecticut, like several other states, uses a "town" system within counties, a fifth letter, or grid, was assigned to designate each of the 169 towns.

We report the first use of the Geo-Code to record the magnitude and intensity of damage due to outbreaks of pest organisms. The Geo-Code could be used to record gypsy moth damage throughout its range in North America and the Old World just as it is used for the gypsy moth and elm spanworm in Connecticut. Use of the Geo-Code in this manner would allow uniformly organized records to be assembled, summarized, and published of the damage caused by any disease organism or insect.

## Methods

The aerial defoliation surveys were made each year in early July after the elm spanworm had ceased feeding and the gypsy moth had discontinued most of its feeding. Two people estimated the intensity of defoliation and recorded its magnitude on a map with a scale of 1:125,000. Intensities were color coded to facilitate recording. A modified acreage grid[3] was used to calculate the acreage defoliated within each town. Ground surveys determined which species were abundant within a particular town.

3. Forestry Suppliers, Inc., Jackson, Miss.

Data from 1969 and 1970 were pooled and presented as noticeable defoliation. The categories were changed in 1971 because they were not satisfactory in showing intensity of defoliation. Four categories, namely 10-25%, 26-50%, 51-75% and 76-100% were used beginning in 1971.

Noticeable defoliation recorded for each county during each year is shown in Table 1. The intensity of defoliation observed in each county for 1971-74 is given in Table 10. The total noticeable defoliation for each town from 1969-1974 is shown in Tables 2-9.

**Table 1. Noticeable defoliation by county in Connecticut (ONUE), 1969-1974**

| Geo-Code | County Name | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | County Acreage |
|---|---|---|---|---|---|---|---|---|
| ONUO | LITCHFIELD | 1491 | 32196 | 60454 | 109790 | 9847 | 32093 | 607168 |
| ONUP | HARTFORD | | 16255 | 70458 | 85210 | 25105 | 7003 | 480128 |
| ONUQ | TOLLAND | | | 18719 | 50705 | 99601 | 29991 | 268848 |
| ONUR | WINDHAM | 1752 | 45005 | 69038 | 35480 | 68465 | 39369 | 332740 |
| ONUS | FAIRFIELD | | 138220 | 188434 | 1920 | | | 422031 |
| ONUT | NEW HAVEN | 1509 | 120128 | 135257 | 48120 | 2103 | | 399016 |
| ONUU | MIDDLESEX | | 20715 | 51369 | 94160 | 27169 | | 248028 |
| ONUV | NEW LONDON | 47883 | 52520 | 60373 | 83075 | 100925 | 12524 | 448508 |
| | TOTAL | 52635 | 425039 | 654102 | 508460 | 333215 | 120980 | 3206467 |

**Table 2. Noticeable defoliation by town in Litchfield County (ONUO), 1969-1974**

| Geo-Code | Town Name | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | Town Acreage |
|---|---|---|---|---|---|---|---|---|
| ONUKZ | BARKHAMSTED | | 400 | 3132 | 6120 | 156 | | 24960 |
| ONUOT | BETHLEHEM | | | | 5040 | | | 12608 |
| ONUOW | BRIDGEWATER | | | 3233 | 2240 | | | 10432 |
| ONUKT | CANAAN | | | | | | | 21376 |
| ONUKV | COLEBROOK | | | | | | | 21120 |
| ONUKW | CORNWALL | | | | 1680 | 428 | 4979 | 29952 |
| ONUKX | GOSHEN | | | | 1800 | | 545 | 29184 |
| ONUOR | HARWINTON | | 6600 | 12444 | 5760 | 195 | | 20096 |
| ONUOK | KENT | | | | 6440 | 5332 | 7040 | 31680 |
| ONUOQ | LITCHFIELD | | 1200 | 5569 | 10800 | 117 | 389 | 36672 |
| ONUOP | MORRIS | | 240 | 39 | 5230 | | | 12032 |
| ONUON | NEW HARTFORD | | 40 | 7497 | 14920 | | | 24512 |
| ONUOS | NEW MILFORD | | | 2862 | 1160 | | | 41126 |
| ONUKU | NORFOLK | | | | | | | 29888 |
| ONUKP | NORTH CANAAN | 172 | | | | | | 12544 |
| ONUOV | PLYMOUTH | 197 | 12576 | 9340 | 840 | | | 14336 |
| ONUOX | ROXBURY | | 60 | 2801 | 5120 | | | 16896 |
| ONUKO | SALISBURY | | | | | | 1673 | 38720 |
| ONUKS | SHARON | | | | | 973 | 11359 | 38592 |
| ONUOU | THOMASTON | | 1520 | 4396 | 1400 | 778 | | 7680 |
| ONUOM | TORRINGTON | | 280 | | 9240 | 1051 | | 25600 |
| ONUOL | WARREN | | | | 10800 | | 6108 | 17920 |
| ONUOO | WASHINGTON | | | | 8120 | | | 24768 |
| ONUOZ | WATERTOWN | 10 | 3840 | 272 | 2320 | | | 19072 |
| ONUKY | WINCHESTER | | | | 2240 | 817 | | 21760 |
| ONUOY | WOODBURY | 1112 | 5440 | 8869 | 8520 | | | 23552 |

## Defoliation, 1969-1974

*Defoliation, 1969*

The gypsy moth defoliated 52,635 acres in 24 towns in four counties in 1969 (Fig. 1). The largest infestation was in the Ledyard-North Stonington area (New London County). Most of the defoliation in the western half of Connecticut occurred near Lake Quasapaug in Woodbury (Litchfield County) and Middlebury (New Haven County).

*Defoliation, 1970*

Defoliation in 85 towns in seven counties covered 425,039 acres in 1970 (Fig. 2). Defoliation was caused mostly by gypsy moth in New London, Windham and Middlesex Counties. Both the gypsy

**Table 3. Noticeable defoliation by town in Hartford County (ONUP), 1969-1974**

| Geo-Code | Town Name | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | Town Acreage |
|---|---|---|---|---|---|---|---|---|
| ONULX | AVON | | | 311 | 7160 | | | 15040 |
| ONUPX | BERLIN | | 3120 | 4007 | 3200 | | | 17280 |
| ONULY | BLOOMFIELD | | | 972 | 1560 | 973 | | 16896 |
| ONUPK | BRISTOL | | 4320 | 7819 | 600 | | | 17024 |
| ONULW | BURLINGTON | | 5120 | 15314 | 11360 | 389 | | 19584 |
| ONULS | CANTON | | | 662 | 2520 | | | 16000 |
| ONULP | EAST GRANBY | | | | 320 | | 856 | 11136 |
| ONUPQ | EAST HARTFORD | | | | | 233 | | 11584 |
| ONULV | EAST WINDSOR | | | | | | 545 | 17152 |
| ONULR | ENFIELD | | | | | | 273 | 21632 |
| ONUPL | FARMINGTON | | 575 | 7517 | 6160 | | | 18368 |
| ONUPV | GLASTONBURY | | | 7731 | 17840 | 7084 | | 33600 |
| ONULO | GRANBY | | 920 | 4852 | 1840 | | 2178 | 26432 |
| ONUPM | HARTFORD | | | | 200 | | | 11776 |
| ONULK | HARTLAND | | | | 4080 | | 389 | 22080 |
| ONUPR | MANCHESTER | | | 992 | 2840 | 4399 | | 17408 |
| ONUPZ | MARLBOROUGH | | | 3427 | 11060 | 6812 | | 15040 |
| ONUPS | NEW BRITAIN | | 200 | 370 | 880 | | | 8512 |
| ONUPT | NEWINGTON | | | 1072 | 440 | | | 8448 |
| ONUPO | PLAINVILLE | | 560 | 487 | 1280 | | | 6336 |
| ONUPY | ROCKY HILL | | | 428 | 1080 | | | 8896 |
| ONULT | SIMSBURY | | | 117 | 3640 | 817 | | 22080 |
| ONUPN | SOUTH WINDSOR | | | | | 1674 | 350 | 18240 |
| ONUPW | SOUTHINGTON | | 1160 | 10464 | 4230 | | | 23616 |
| ONULQ | SUFFIELD | | | | | | 1478 | 27584 |
| ONUPP | WEST HARTFORD | | 280 | 3038 | 2600 | | | 14208 |
| ONUPU | WETHERSFIELD | | | 312 | 160 | | | 8320 |
| ONULZ | WINDSOR | | | 566 | 160 | 2724 | 623 | 19968 |
| ONULU | WINDSOR LOCKS | | | | | | 311 | 5888 |

**Table 4. Noticeable defoliation by town in Tolland County (ONUQ), 1969-1974**

| Geo-Code | Town Name | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | Town Acreage |
|---|---|---|---|---|---|---|---|---|
| ONUQX | ANDOVER | | | 1478 | 3480 | 5215 | | 9984 |
| ONUQS | BOLTON | | | 2490 | 1595 | 4437 | | 9920 |
| ONUQY | COLUMBIA | | | 409 | 2360 | 4904 | 78 | 13952 |
| ONUQT | COVENTRY | | | | 7280 | 5838 | 234 | 23872 |
| ONUQL | ELLINGTON | | | 312 | 640 | 5994 | 1867 | 22144 |
| ONUQW | HEBRON | | | 440 | 11840 | 4904 | 156 | 24000 |
| ONUQZ | MANSFIELD | | | 7264 | 8480 | 9769 | | 28928 |
| ONUQK | SOMERS | | | | | 2725 | 1594 | 18368 |
| ONUQQ | STAFFORD | | | 1149 | 3040 | 19383 | 8752 | 38512 |
| ONUQP | TOLLAND | | | 2560 | 3320 | 13350 | 3384 | 25856 |
| ONUQR | UNION | | | | | 8330 | 13420 | 19136 |
| ONUQO | VERNON | | | 273 | 590 | 4476 | 39 | 11904 |
| ONUQU | WILLINGTON | | | 2344 | 8080 | 10276 | 467 | 22272 |

moth and elm spanworm were responsible for defoliation in New Haven, Fairfield, Litchfield and Hartford Counties. The elm spanworm was usually more abundant in the western part of the state. North Stonington, Canterbury, Redding, Oxford, Ridgefield and Newtown each had more than 15,000 acres defoliated. Six other towns had between 10,000 to 14,999 acres of defoliation. Twenty more towns had from 5,000 to 9,999 acres defoliated.

*Defoliation, 1971*

Defoliation totaled 654,102 acres in 127 towns in all eight counties in 1971 (Fig. 3). The gypsy moth caused defoliation east of the Connecticut River in Tolland, Windham, and New London Counties, and in portions of Middlesex and Hartford Counties. Both the gypsy moth and the elm spanworm were present in Fairfield, New Haven and Litchfield Counties, and in portions of Hartford and Middlesex Counties. West of the Connecticut River, gypsy moth tended to be more abundant in the northern and eastern areas, whereas the elm spanworm often seemed to be most abundant elsewhere.

Defoliation was most severe in New Haven and

**Table 5. Noticeable defoliation by town in Windham County (ONUR), 1969-1974**

| Geo-Code | Town Name | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | Town Acreage |
|---|---|---|---|---|---|---|---|---|
| ONURK | ASHFORD | | | 1344 | 6800 | 15414 | 1050 | 25792 |
| ONURU | BROOKLYN | | 1240 | 9007 | 2240 | 4204 | 3929 | 18368 |
| ONURX | CANTERBURY | 875 | 20000 | 16016 | 880 | 350 | 4512 | 25600 |
| ONURO | CHAPLIN | | 785 | 2590 | 2640 | 4632 | 350 | 12672 |
| ONURL | EASTFORD | | | | 2720 | 4320 | 3579 | 18304 |
| ONURT | HAMPTON | | 4680 | 8564 | | 5060 | 1907 | 16192 |
| ONURV | KILLINGLY | | | 78 | 1280 | 11249 | 6496 | 32000 |
| ONURY | PLAINFIELD | 644 | 2020 | 7421 | 4600 | 1168 | 856 | 27328 |
| ONURP | POMFRET | | 1680 | 7026 | | 5683 | 3890 | 25984 |
| ONURQ | PUTNAM | | | | | | 2062 | 12864 |
| ONURW | SCOTLAND | 233 | 9600 | 8507 | 120 | 1946 | 351 | 11716 |
| ONURZ | STERLING | | | 2805 | 11640 | 4203 | 117 | 17408 |
| ONURN | THOMPSON | | | | | | | 31168 |
| ONURS | WINDHAM | | 5000 | 5680 | 2560 | 5799 | 428 | 17920 |
| ONURM | WOODSTOCK | | | | | 4437 | 9842 | 39424 |

**Table 6. Noticeable defoliation by town in Fairfield County (ONUS), 1969-1974**

| Geo-Code | Town Name | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | Town Acreage |
|---|---|---|---|---|---|---|---|---|
| ONUSP | BETHEL | | 4760 | 5057 | | | | 10880 |
| ONUSZ | BRIDGEPORT | | | 467 | | | | 11200 |
| ONUSM | BROOKFIELD | | | 6005 | 960 | | | 12672 |
| ONUSO | DANBURY | | 14160 | 13811 | | | | 28160 |
| ONUWO | DARIEN | | | 1538 | | | | 9536 |
| ONUSY | EASTON | | 3720 | 7430 | | | | 18432 |
| ONUWN | FAIRFIELD | | | 6516 | | | | 19584 |
| ONUWK | GREENWICH | | 800 | 2013 | | | | 32384 |
| ONUSQ | MONROE | | 13240 | 12209 | | | | 16896 |
| ONUWM | NEW CANAAN | | 8400 | 7112 | | | | 14812 |
| ONUSL | NEW FAIRFIELD | | 1800 | 11781 | | | | 16512 |
| ONUSN | NEWTOWN | | 18000 | 24012 | 680 | | | 38643 |
| ONUWP | NORWALK | | 920 | 1733 | | | | 17728 |
| ONUST | REDDING | | 18120 | 13633 | | | | 20608 |
| ONUSS | RIDGEFIELD | | 21040 | 20909 | | | | 22400 |
| ONUSR | SHELTON | | 8000 | 14408 | | | | 20096 |
| ONUSK | SHERMAN | | | 5880 | 280 | | | 15040 |
| ONUWL | STAMFORD | | 2640 | 6030 | | | | 24640 |
| ONUSV | STRATFORD | | | 3446 | | | | 11968 |
| ONUSU | TRUMBULL | | 1240 | 6076 | | | | 15040 |
| ONUSX | WESTON | | 8000 | 9786 | | | | 13312 |
| ONUWQ | WESTPORT | | | 3019 | | | | 14336 |
| ONUSW | WILTON | | 13880 | 5563 | | | | 17152 |

Fairfield Counties where it occurred in all towns. Ridgefield and Newtown (Fairfield County) each had more than 20,000 acres defoliated greater than 51%. Southbury (New Haven County), North Stonington and Voluntown (New London County), Canterbury (Windham County) and Burlington (Hartford County), each had 15,000 to 19,999 acres defoliated. Ten other towns had between 10,000 to 14,999 acres defoliated. Another 38 towns had 5,000 to 9,999 acres defoliated. Defoliation in excess of 51% was recorded upon 10,000 to 14,999 acres in eight towns and to the same degree on from 5,000 to

**Table 7. Noticeable defoliation by town in New Haven County (ONUT), 1969-1974**

| Geo-Code | Town Name | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | Town Acreage |
|---|---|---|---|---|---|---|---|---|
| ONUTX | ANSONIA | | 840 | 1673 | | | | 3968 |
| ONUTT | BEACON FALLS | 112 | 5872 | 1556 | | | | 6472 |
| ONUTU | BETHANY | 102 | 12840 | 9880 | 600 | | | 13440 |
| ONUXR | BRANFORD | | | 993 | 1920 | 195 | | 17856 |
| ONUTR | CHESHIRE | | 4000 | 13202 | 1240 | | | 21120 |
| ONUTW | DERBY | | 1040 | 1169 | | | | 3392 |
| ONUXQ | EAST HAVEN | | | 933 | 720 | | | 8064 |
| ONUXM | GUILFORD | | 200 | 3621 | 11880 | 623 | | 30464 |
| ONUXO | HAMDEN | | 5800 | 10354 | 1200 | | | 21120 |
| ONUXN | MADISON | | 640 | 8774 | 9160 | 507 | | 23232 |
| ONUTV | MERIDEN | | 3080 | 3272 | 4080 | | | 15360 |
| ONUTL | MIDDLEBURY | 1002 | 8640 | 5002 | 640 | | | 11520 |
| ONUXS | MILFORD | | | 2317 | | | | 15240 |
| ONUTP | NAUGATUCK | | 7640 | 4102 | 160 | | | 10368 |
| ONUXP | NEW HAVEN | | 80 | 992 | | | | 13504 |
| ONUXL | NORTH BRANFORD | | 560 | 5200 | 6400 | 389 | | 17112 |
| ONUXK | NORTH HAVEN | | | 2611 | 1640 | | | 13440 |
| ONUXT | ORANGE | | 120 | 2707 | | | | 11264 |
| ONUTO | OXFORD | | 20240 | 760 | | | | 21120 |
| ONUTQ | PROSPECT | | 8472 | 7800 | | | | 9152 |
| ONUTS | SEYMOUR | 10 | 6000 | 1791 | | 117 | | 9408 |
| ONUTK | SOUTHBURY | 242 | 6480 | 17116 | 1160 | | | 26176 |
| ONUTZ | WALLINGFORD | | 200 | 5389 | 5000 | 272 | | 25472 |
| ONUTM | WATERBURY | 30 | 5480 | 5679 | 120 | | | 18432 |
| ONUXU | WEST HAVEN | | | 839 | | | | 6784 |
| ONUTN | WOLCOTT | 11 | 12344 | 9278 | 2200 | | | 13184 |
| ONUXV | WOODBRIDGE | | 9560 | 8247 | | | | 12352 |

**Table 8. Noticeable defoliation by town in Middlesex County (ONUU), 1969-1974**

| Geo-Code | Town Name | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | Town Acreage |
|---|---|---|---|---|---|---|---|---|
| ONUUT | CHESTER | | | 1206 | 4200 | 1246 | | 10176 |
| ONUUW | CLINTON | | | | 2800 | | | 11008 |
| ONUUL | CROMWELL | | | 582 | 400 | 506 | | 8640 |
| ONUUU | DEEP RIVER | | | 840 | 2440 | 272 | | 9088 |
| ONUUP | DURHAM | | 4300 | 3174 | 1560 | | | 14912 |
| ONUUR | EAST HADDAM | | | 1677 | 25160 | 17165 | | 36864 |
| ONUUN | EAST HAMPTON | | | 3272 | 17440 | 5683 | | 23552 |
| ONUUV | ESSEX | | 195 | 585 | 400 | | | 7808 |
| ONUUQ | HADDAM | | 3360 | 6962 | 14640 | 1635 | | 29888 |
| ONUUS | KILLINGWORTH | | 20 | 11316 | 9720 | 195 | | 23040 |
| ONUUK | MIDDLETOWN | | 4680 | 9385 | 4240 | | | 27392 |
| ONUUO | MIDDLEFIELD | | | 1149 | 1040 | | | 8412 |
| ONUUY | OLD SAYBROOK | | 4860 | 622 | 40 | | | 11712 |
| ONUUM | PORTLAND | | | 7153 | 8280 | 467 | | 15168 |
| ONUUX | WESTBROOK | | 3300 | 3446 | 1800 | | | 10368 |

9,999 acres in another 19 towns. Madison, Burlington and Southbury, each had more than 5,000 acres almost completely defoliated (76-100%).

*Defoliation, 1972*

Defoliation in 1972 was not as severe as in 1971, but noticeable defoliation totalled 508,460 acres. This was 145,642 acres less than the year before (Fig. 4). Most of the defoliation in eastern Connecticut (New London, Tolland and Windham Counties) was caused by the gypsy moth. Elsewhere it was often caused by both insects except in Granby and Hartland (Hartford County) and in Barkhamsted (Litchfield County) where it was caused entirely by the gypsy moth.

Some defoliation was recorded in 117 towns in all eight counties. Towns with the largest acreages affected included East Haddam with more than 25,000 acres, and Glastonbury and East Hampton with 15,000 to 19,999 acres. Defoliation of 10,000 to 14,999 acres was recorded in 11 other towns and defoliation of 5,000 to 9,999 acres was recorded in another 24 towns.

The largest areas in the 76-100% category were in Litchfield and Windham Counties where 9,310 and 5,400 acres respectively were almost completely defoliated. Over three quarters of the defoliation in Middlesex County was 51% or greater.

*Defoliation, 1973*

Defoliation in 1973 totalled 333,215 acres, 175,245 acres less than the year before, virtually all caused by the gypsy moth. Less than 50 acres were infested by the elm spanworm. This outbreak occurred in East Haddam.

Defoliation was recorded in 78 towns in seven counties, but most of it occurred east of the Connecticut River (Fig. 5). Colchester, East Haddam, Stafford and Ashford each had more than 15,000 acres defoliated. Seven towns had 10,000 to 14,999 acres defoliated and 15 others had 5,000 to 9,999 acres affected. The intensity of defoliation was greatest in Tolland and New London Counties.

*Defoliation, 1974*

Defoliation totalled 120,980 acres, 212,235 less than in 1973 (Fig. 6). This year, too, all defoliation was caused by the gypsy moth.

Some defoliation was recorded in 56 towns in five counties, but most occurred in Litchfield, Tolland and Windham Counties. The towns of Sharon and Union each had 10,000 to 14,999 acres defoliated; five other towns had 5,000 to 9,999 acres defoliated. The intensity of defoliation was greatest in Litchfield and Windham Counties.

## Tree Mortality

Stephens (1971) reported that trees growing on rocky, shallow soils, which had been defoliated in successive years, had a death rate over a decade about twice that of undefoliated trees growing under similar soil conditions. However, more recently the findings of Dunbar and Stephens (ms. submitted) have shown oak mortalities as high as 79% on shallow, rocky soils following two or more

**Table 9. Noticeable defoliation by town in New London County (ONUV), 1969-1974**

| Town Name | Geo-Code | Acres/Year 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | Town Acreage |
|---|---|---|---|---|---|---|---|---|
| ONUVO | BOZRAH | 212 | | | 320 | 6306 | 2022 | 12800 |
| ONUVK | COLCHESTER | | | | 13520 | 15997 | 195 | 31100 |
| ONUVY | EAST LYME | | | | 7300 | 10276 | 1985 | 22272 |
| ONUVP | FRANKLIN | | | 390 | 600 | 3036 | 1011 | 12800 |
| ONUVM | GRISWOLD | 3142 | 9560 | 8865 | 1200 | 311 | 739 | 24064 |
| ONUZP | GROTON | 6000 | 8760 | 4247 | 1280 | 1557 | 311 | 24512 |
| ONUVL | LEBANON | | | | 3040 | 9925 | 816 | 35904 |
| ONUZL | LEDYARD | 19145 | 1320 | | | 2336 | 233 | 25920 |
| ONUVR | LISBON | 1462 | 2560 | 1987 | 5240 | 1207 | 117 | 10560 |
| ONUVW | LYME | | | 700 | 8515 | 12572 | | 21120 |
| ONUVT | MONTVILLE | 320 | | | 4520 | 10703 | 1828 | 28096 |
| ONUZK | NEW LONDON | | 80 | | | 156 | 39 | 4672 |
| ONUZM | NORTH STONINGTON | 8113 | 17960 | 18685 | 8720 | 428 | | 36032 |
| ONUVU | NORWICH | 140 | 360 | | 2200 | 1985 | 311 | 17344 |
| ONUVX | OLD LYME | | | | 1840 | 6655 | 778 | 17344 |
| ONUVV | PRESTON | 7872 | 5360 | 117 | 1480 | 78 | | 20032 |
| ONUVS | SALEM | | | | 11600 | 10392 | | 19136 |
| ONUVQ | SPRAGUE | 1477 | 1560 | 2035 | 1960 | 2413 | 739 | 8576 |
| ONUZQ | STONINGTON | | 4720 | 6737 | 4700 | 1401 | | 27328 |
| ONUVN | VOLUNTOWN | | 160 | 16610 | 4240 | | 156 | 25408 |
| ONUVZ | WATERFORD | | 120 | | 800 | 3191 | 1244 | 23488 |

**Table 10. Intensity of defoliation by county in Connecticut (ONUE), 1969-1974**

| Geo-Code | County | Year | Acres/Percent Defoliation 10-25 | 26-50 | 51-75 | 76-100 | Total Defoliation | County Acreage |
|---|---|---|---|---|---|---|---|---|
| ONUO | LITCHFIELD | 1971 | 9751 | 11462 | 31939 | 7302 | 60454 | 607168 |
| | | 1972 | 9360 | 64600 | 26520 | 9310 | 109790 | |
| | | 1973 | 156 | 2879 | 5489 | 1323 | 9847 | |
| | | 1974 | 1167 | 12370 | 7858 | 10698 | 32093 | |
| ONUP | HARTFORD | 1971 | 17534 | 6561 | 30726 | 15637 | 70458 | 480128 |
| | | 1972 | 6550 | 36240 | 38740 | 3680 | 85210 | |
| | | 1973 | 156 | 10976 | 13544 | 429 | 25105 | |
| | | 1974 | | 3307 | 2374 | 1322 | 7003 | |
| ONUQ | TOLLAND | 1971 | 9367 | 4124 | 3805 | 1423 | 18719 | 268848 |
| | | 1972 | 7790 | 18875 | 20360 | 3680 | 50705 | |
| | | 1973 | 1246 | 37831 | 45150 | 15374 | 99601 | |
| | | 1974 | 2296 | 10113 | 14198 | 3384 | 29991 | |
| ONUR | WINDHAM | 1971 | 7030 | 18885 | 38624 | 4499 | 69038 | 332740 |
| | | 1972 | 2560 | 16520 | 11000 | 5400 | 35480 | |
| | | 1973 | 2958 | 44799 | 19384 | 1324 | 68465 | |
| | | 1974 | 8131 | 17894 | 12137 | 1207 | 39369 | |
| ONUS | FAIRFIELD | 1971 | 11987 | 32384 | 123707 | 20356 | 188434 | 422031 |
| | | 1972 | 680 | 1240 | | | 1920 | |
| | | 1973 | | | | | | |
| | | 1974 | | | | | | |
| ONUT | NEW HAVEN | 1971 | 7302 | 36604 | 65248 | 26103 | 135257 | 399016 |
| | | 1972 | 5600 | 27520 | 14080 | 920 | 48120 | |
| | | 1973 | 896 | 856 | 351 | | 2103 | |
| | | 1974 | | | | | | |
| ONUU | MIDDLESEX | 1971 | 8272 | 25354 | 10045 | 7698 | 51369 | 248028 |
| | | 1972 | 3520 | 18640 | 71880 | 120 | 94160 | |
| | | 1973 | 1985 | 11561 | 12727 | 896 | 27169 | |
| | | 1974 | | | | | | |
| ONUV | NEW LONDON | 1971 | 14383 | 18667 | 19303 | 8020 | 60373 | 448576 |
| | | 1972 | 9435 | 49160 | 24280 | 200 | 83075 | |
| | | 1973 | 117 | 38300 | 53127 | 9381 | 100925 | |
| | | 1974 | 6301 | 4783 | 1245 | 195 | 12524 | |

successive defoliations. Based upon the defoliation figures for the past six years and the recent findings of Dunbar and Stephens, it appears that high tree mortality, particularly among oaks, may occur in several areas where severe defoliation has occurred for two or more successive years on sites with shallow, rocky soils.

### Termination and Duration of Outbreaks

Outbreaks of gypsy moth and elm spanworm ultimately collapse from natural causes. The nuclear polyhedrosis virus is the primary biotic agent terminating gypsy moth outbreaks (Campbell 1963b, Doane 1970), although another pathogen, *Streptococcus faecalis*, is also important (Doane and Redys 1970). Gypsy moth populations also tend to decrease as defoliation approaches 100% (Campbell 1973). Not only is the insects' food supply exhausted, but female larvae and pupae, in particular, often die from desiccation (Campbell 1973) and from the stinging of ichneumonids (Campbell 1963a). Desiccation may be a symptom of infection by *S. faecalis* (Doane and Redys 1970).

The significance of precipitation, mean minimum winter temperatures and availability of favorable food plants in the termination of outbreaks of gypsy moths were also discussed by Campbell (1973). Friend (1945) suggested that winter temperatures were not a significant factor in suppressing gypsy moth populations in Connecticut.

The causes of natural population collapses of the gypsy moth were not documented during the period covered by this report. Epizootics and starvation presumably were the primary causes.

Egg parasitoids are the principal biological agents causing the collapse of outbreaks of the elm spanworm (Ciesla 1964, Kaya and Anderson 1974). *Telenomus alsophilae* Viereck played a significant role in reducing the numbers of elm spanworm toward the end of the outbreak in the southern Appalachians (Ciesla 1964). Late spring frosts which killed the foliage and resulted in starvation of early instar larvae also played a role in the termination of that outbreak, (Ciesla 1963, Drooz 1972), as did shortages of foliage following single (Ciesla 1963) and successive defoliations (Drooz 1970, 1971).

The collapse of the elm spanworm outbreak in Connecticut has been thoroughly documented (Kaya and Anderson 1972, 1974, Anderson and Kaya 1973). *Ooencyrtus ennomus* Yoshimoto, a species that soon will be described, (C. M. Yoshimoto, personal communication)[4] caused the collapse in southwestern Connecticut in 1971, and in all other areas of the state in 1972 and 1973. It took no more than two years for collapse to occur in any given area of the state. Other parasitoids and reduction of quantity of food were not significant factors. Disease was not important in terminating the Connecticut or the southern Appalachian outbreaks (Fedde 1964).

Prior to 1965, gypsy moth outbreaks in Connecticut usually lasted only one, two, or three years. On two occasions, towns received defoliation for six consecutive years. Defoliation was recorded for five consecutive years in one other town and for four years in five other towns. Gypsy moth defoliation continued in Ledyard for six years starting in 1965. Eight consecutive years of defoliation started in Groton during 1967, and seven consecutive years of defoliation began in Sprague during 1968. Six consecutive years of defoliation in North Stonington and Preston began during 1967. Six consecutive years of defoliation started in Plainfield, Griswold, Canterbury, Scotland, and Lisbon during 1969.

The number of consecutive years of defoliation experienced in a given town is still usually three or less, although the number of towns where defoliation occurred for more than three years increased significantly during 1969-1974. The occurrence of successive years of defoliation is listed below. There were four towns where defoliation did not occur.

**Consecutive Years of Defoliation In Connecticut Towns. 1969 - 1974**

| Years of Defoliation | Towns |
|---|---|
| 2 | 46 |
| 3 | 52 |
| 4 | 31 |
| 5 | 6 |
| 6 | 7 |

Infestations of gypsy moths are no longer suppressed in Connecticut as they were prior to World War II (Friend 1945) and as late as 1963 (Turner 1963a). Some towns undertook suppression programs as late as 1971, but the majority decided to leave control efforts to individual landowners. The persistence of outbreaks in recent years may be indicative of the lack of control efforts or of better recording procedures.

### Effects of Aerial Spraying on Defoliation

A few towns attempted to suppress the gypsy moth and elm spanworm using carbaryl from the air. Towns that were sprayed and the acreages treated are shown in Table 11. The results of six of the larger spraying programs are summarized below.

Woodland in the western half of Ledyard and northern part of Groton was sprayed in 1969. Large numbers of gypsy moth caterpillars were killed, but

4. This parasitoid of the elm spanworm was initially incorrectly identified as *Ooencyrtus clisiocampae* (Ashmead).

**Table 11. Towns that aerial sprayed with carbaryl, 1969-71.** [1]

| Year | Town | Number acres sprayed |
|---|---|---|
| 1969 | Groton | 2,885 |
| | Ledyard | 13,115 |
| | Sprague | 2,030 |
| 1970 | Ledyard | 8,500 |
| | Lisbon | 950 |
| | Sprague | 750 |
| 1971 | Beacon Falls | 3,225 |
| | Derby | 160 |
| | Durham | 2,637 |
| | Haddam | 6,197 |
| | Old Saybrook | 4,165 |
| | Oxford | 15,450 |
| | Plainville | 785 |
| | Prospect | 5,672 |
| | Wilton | 2,588 |

[1] Aerial spraying was carried out in several state parks and on a number of private properties in addition to the town spraying programs.

spraying did not prevent noticeable defoliation from occurring, nor did it prevent an outbreak of gypsy moths in some of the woodland in 1970. Inadequate mixing of the finished spray mixture was responsible in large part for the ineffectiveness.

A total of 8,500 acres in eastern Ledyard was treated in 1970. This prevented defoliation in treated areas. The areas that were left untreated were defoliated. The gypsy moth did not reach outbreak levels in Ledyard during 1971, but it is impossible to tell if spraying was responsible or if the infestation had collapsed naturally. North of Ledyard, in the southern part of Preston where no aerial spraying occurred, the gypsy moth population collapsed naturally. To the south of Ledyard, in Groton, no aerial spraying occurred in 1970, and the outbreak continued during 1971.

Old Saybrook sprayed 4,165 acres in 1971. This program prevented defoliation in the treated areas and reduced gypsy moths to such a low level that an outbreak did not occur in 1972.

Haddam sprayed 6,197 acres in 1971. Considerable defoliation was recorded, but most of it occurred in unsprayed woodland.

Oxford was also sprayed in 1971. Defoliation was prevented on the 15,450 treated acres. In 1972, little defoliation occurred in surrounding towns that had not been sprayed because gypsy moth and elm spanworm populations had collapsed from natural causes throughout much of the region. These data suggest that extensive defoliation would have been prevented in Oxford in 1972, even without spraying the previous year.

Prospect had an aerial spraying program in 1971 but it was delayed until considerable defoliation had already occurred. The lower intensity of defoliation in the treated southern part of the town compared to that recorded for the unsprayed northern part of Bethany indicated that some foliage protection was achieved. No defoliation occurred in Prospect during 1972; little also occurred in surrounding towns which had not been sprayed the year before. These data, like those presented in the previous paragraph, suggest that no defoliation would have occurred in Prospect during 1972 even if the town had not been sprayed in 1971.

## Dispersal

The gypsy moth disperses naturally as wind-blown first instar larvae (Burgess 1913, Collins 1915). Long distance movement such as its introduction into the United States in the late 1860's and transportation into new areas is caused by man. The dispersal mechanisms of the elm spanworm are less well known. Wind-blown newly-hatched larvae (Taylor and Tsao 1962, Drooz 1970) or migrating females (Fedde 1964) may be responsible for dispersal. References to air currents carrying large numbers of larvae up mountain slopes (Fedde 1964, Drooz 1970, 1971) coupled with the low proportion of females in the commonly observed adult flights (Taylor and Tsao 1962, Fedde 1964, Lund 1965) suggest that dispersal is primarily by wind-blown larvae. Figures 1-6 illustrate the general northward and eastward movement of infestations of the gypsy moth and elm spanworm during 1969-74.

The gypsy moth infestation in the Ledyard-North Stonington area in 1969, with scattered outbreaks as far north as Scotland, Canterbury and Plainfield, appeared to have moved in part north and eastward, reaching Killingly and Putnam five years later. Other portions of the infestation appear to have coalesced in 1973 with a larger infestation to the northwest in the Ashford-Willington area.

In 1970, the gypsy moth had dispersed eastward in North Stonington to the Rhode Island border, to the northeast in Preston and Griswold and to the north in Plainfield. The scattered infestations in Canterbury, Lisbon, Scotland and Sprague in 1969 became a general outbreak in 1970 and spread northward into Brooklyn, Pomfret, Hampton and Chaplin, and westward into Windham. In 1971 the infestation near the Connecticut-Rhode Island border extended from Stonington to Sterling. Defoliation had progressed northward in Pomfret and north-westward into Mansfield, Willington, and Ashford. The infestation continued northward along the Connecticut-Rhode Island border during 1972, reaching into southern Killingly. Its northward spread continued in 1973 with defoliation occurring in central and northern Killingly. The infestation reached into Putnam in 1974. A general

infestation with multiple origins, including the Ledyard-Canterbury infestation of 1969, was evident to the north and south of the Ashford-Willington area in 1973 and in the Stafford-Union-Woodstock areas in 1974.

The large infestation comprised of both species in the western half of Connecticut in 1970 moved east and north in succeeding years. In 1971, defoliation spread into towns to the north and east of those infested the previous year. Along the eastern side of the Connecticut River, gypsy moth outbreaks arose independently from, or were extensions of, infestations just to the west of the river. Dispersal continued in easterly and northerly directions in 1972. Defoliation was prevalent in towns to the north of those defoliated the previous year, and in many towns to the east of the Connecticut River but west of the Thames River. Many infestations which may have arisen independently in previous years were engulfed by the larger infestation that was spreading across the state. Gypsy moth outbreaks along the Connecticut-New York border occurred for the first time in Sharon and Cornwall during 1973, and were probably extensions of the infestations to the south in previous years. To the east of the Connecticut River, infestations of gypsy moth had dispersed eastward and northward into areas not defoliated the year before.

In 1974, outbreaks of gypsy moth near the Connecticut-New York border occurred for the first time in southern Salisbury, and had moved eastward through Warren and Cornwall into Goshen and Litchfield. It is possible that the outbreaks in northwestern Salisbury arose from infestations to the west in New York State. Infestations east of the Connecticut River were most extensive in towns bordering Massachusetts.

The dispersal of the gypsy moth (Burgess 1913) and apparently of the elm spanworm is passive and in the direction of the prevailing winds. In Connecticut prevailing winds from May to October are southerly and southwesterly along the coastal plain and into the central lowlands (Brumbach 1965). Local winds differing from these paths exist.

Dispersal of newly-hatched larvae may occur in Connecticut from about April 27 to May 21. Gypsy moth dispersal may occur at wind velocities as low as 2 mph (Collins 1915), although most dispersal apparently occurs at velocities of 8-15 mph or more (Collins 1915, Burgess 1913, Minnott 1922). Even though some dispersal may occur at temperatures below 55°F (Leonard 1971), most occurs above 55°F (Burgess 1913, Collins 1915, Leonard 1971). Few larvae are dispersed during periods of rain or darkness (Leonard 1971).

To assess more closely the role of wind, weather data from two locations were examined for the periods when larvae were most likely to have dispersed. The wind directions at three-hour intervals during the day when temperatures were 55°F or above and no precipitation recorded were calculated from April 27 to May 21 for 1969-74. The publications, Climatological Data for Hartford and Bridgeport, were used to compile the statistics. In Hartford, the wind tended to blow more often out of the southeast than from the other directions (Table 12). The wind blew less often from the northeast than from the other quadrants, and significantly so in comparison to at least one other quadrant during four of the years. In Bridgeport, the wind blew more frequently from the southwest than any of the other quadrants in all six years. The wind blew significantly more often from this direction than at least one other direction in four of the years.

**Table 12. Frequency of wind flow from specific directional quadrants during April 2 through May 21, 1969-74.**

| Weather station | Year | Total number of recordings | Percentage of wind recordings from specific directions [2] | | | |
|---|---|---|---|---|---|---|
| | | | NE | SE | SW | NW |
| Hartford | 1969 | 110 | 11.8a [3] | 33.6 b | 26.4ab | 28.2ab |
| | 1970 | 108 | 13.8a | 35.1 b | 25.0ab | 25.9ab |
| | 1971 | 67 | 20.8a | 25.3a | 23.8a | 29.9a |
| | 1972 | 91 | 15.3a | 28.5a | 27.4a | 28.5a |
| | 1973 | 90 | 11.0a | 38.9 b | 24.4ab | 25.6 b |
| | 1974 | 87 | 12.6a | 32.2 b | 18.4ab | 36.8 b |
| Bridgeport | 1969 [1] | 94 | 6.4a | 18.1a | 60.6 b | 14.9a |
| | 1970 | 106 | 25.4a | 24.5a | 34.9a | 15.1a |
| | 1971 | 70 | 17.1a | 17.1a | 38.6a | 27.1a |
| | 1972 | 96 | 26.0ab | 26.0ab | 35.4a | 12.5 b |
| | 1973 | 72 | 8.3a | 27.8ab | 47.2 b | 16.7a |
| | 1974 | 94 | 10.6a | 16.0a | 52.1 b | 21.3a |

[1] The 3 hr wind velocities were not published from Bridgeport during April 27 through April 30, 1969.

[2] Wind directions were calculated from data recorded when daylight temperatures were 55° or higher and when there was no precipitation.

[3] Percentages in same row followed by same letter not significantly different at 5% probability level by chi-square analysis using Yate's correction factor.

The frequencies with which winds blew at 11 mph or more from a given cardinal direction were calculated as shown in Table 13. Winds blew more frequently from the south than from the north during each of the six years in Hartford and five of the years in Bridgeport, and significantly so in two of the years in both locations. Winds out of the west occurred more frequently than those from the east in all six years in Hartford and Bridgeport. They blew significantly more often from the west in Bridgeport in 1969, 1973 and 1974.

**Table 13. Frequency of wind flow from the north and south and from the east and west during April 27 through May 21, 1969-74 when wind velocities were 11 or more mph.**

| Weather station | Year | Total number of recordings | Percentage of wind recordings from specific directions[2] | | | |
|---|---|---|---|---|---|---|
| | | | N | S | E | W |
| Hartford | 1969 | 82 | 36.6a[3] | 63.4 b | 40.2a | 59.8a |
| | 1970 | 57 | 26.3a | 73.7 b | 45.6a | 54.4a |
| | 1971 | 35 | 42.9a | 57.1a | 37.1a | 62.9a |
| | 1972 | 37 | 43.2a | 56.8a | 32.4a | 67.6a |
| | 1973 | 53 | 30.2a | 69.8a | 47.2a | 52.8a |
| | 1974 | 48 | 42.0a | 58.0a | 46.0a | 54.0a |
| Bridgeport | 1969[1] | 70 | 17.1a | 82.9 b | 17.1a | 82.9 b |
| | 1970 | 58 | 50.0a | 50.0a | 43.1a | 56.9a |
| | 1971 | 43 | 41.9a | 58.1a | 34.9a | 65.1a |
| | 1972 | 60 | 43.3a | 56.7a | 46.7a | 53.3a |
| | 1973 | 51 | 23.5a | 76.5 b | 23.5a | 76.5 b |
| | 1974 | 59 | 40.1a | 59.9a | 18.6a | 81.4 b |

[1]The 3 hr wind velocities were not published from Bridgeport during April 27 through April 30, 1969.

[2]Wind directions were calculated from data recorded when daylight temperatures were 55° or higher and when there was no precipitation.

[3]$X^2$ analyses were run comparing the frequency with which the wind blew from the north and the south, and from the west and the east. Percentages in the same row under the columns headed N & S followed by same letter were not significantly different at 5% probability level by chi square analysis. Similarly, percentages in the same row under the columns headed E & W followed by the same letter were not significantly different at 5% probability level by chi square analysis. Yate's correction factor was used in all analyses.

During that time of the year when gypsy moth and elm spanworm larvae were most likely to disperse, winds of 11 mph or more tended to occur more frequently from the west than from the east and from the south than from the north. Southwesterly winds prevailed along the shore in Bridgeport. In the upland region in Hartford, winds blew more often out of the southeast and less often from the northeast. Where winds occur frequently from the southeast, dispersal may be to the northwest although prevailing westerly winds may often offset the movement to the west. It would appear that the general spread of these insects to the north and east during 1969-1974 is a result of winds tending to blow more frequently from the south and west.

Data show that outbreaks of gypsy moth are now persisting for longer periods of time, and that the main directions of dispersal are to the north and east. It thus appears that future infestations in southern or western areas of Connecticut may spread across the state and even into adjacent states as the infestations have done during the early 1970's.

## Acknowledgements

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## References Cited


Anderson, J. F. and H. K. Kaya. 1973. Influence of elm spanworm oviposition sites on parasitism by *Ooencyrtus clisiocampae* and *Telenomus alsophilae*. Environ. Entomol. 2: 705-11.

Brumbach, J. J. 1965. The climate of Connecticut. State Geol. and Nat. Hist. Sur. Conn. Bull. 99: 215 p.

Burgess, A. F. 1913. The dispersion of the gypsy moth. USDA Bur. Entomol. Bull. 119: 1-62.

Campbell, R. W. 1963a. Some ichneumonid-sarcophagid interactions in the gypsy moth *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae). Can. Entomol. 95: 337-45.

Campbell, R. W. 1963b. The role of disease and desiccation in the population dynamics of the gypsy moth *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae). Can. Entomol. 95: 426-435.

Campbell, R.W. 1973. Forecasting gypsy moth egg-mass density. USDA For. Ser. Res. Paper NE-268: 1-19.

Chapman, R. N. 1915. Observations on the life history of *Agrilus bilineatus*. J. Agr. Res. 3: 283-93.

Ciesla, W. M. 1963. Decline of the elm spanworm outbreak. For. Farmer 23: 14, 28, 29.

Ciesla, W. M. 1964. Egg parasites of the elm spanworm in the Southern Appalachian Mountains. J. Econ. Entomol. 57: 837-38.

Collins, C. W. 1915. Dispersion of the gypsy-moth larvae by the wind. USDA Bull. 273: 1-23.

Doane, C. C. 1970. Primary pathogens and their role in the development of an epizootic in the gypsy moth. J. Invert. Pathol. 15: 21-33.

Doane, C. C. and J. J. Redys. 1970. Characteristics of motile strains of *Streptococcus faecalis* pathogenic to larvae of the gypsy moth. J. Invert. Pathol. 15: 420-30.

Drooz, A. T. 1970. The elm spanworm (Lepidoptera: Geometridae): How several natural diets affect its biology. Ann. Entomol. Soc. Amer. 63: 391-97.

Drooz, A.T. 1971. The elm spanworm (Lepidoptera: Geometridae): Natural diets and their effect on the F2 generation. Ann. Entomol. Soc. Amer. 64: 331-33.

Drooz, A. T. 1972. Laboratory studies of several natural diets on elm spanworm biology. Proc. Int. Cong. Entomol. 13: 25.

Fedde, G. F. 1964. Elm spanworm, a pest of hardwood forests in the Southern Appalachians. J. For. 62: 102-6.

Friend, R. B. 1945. The gypsy moth in Connecticut. Trans. Conn. Acad. Arts, Sci. 36: 607-629.

Gould, S.W. 1968. Geo-Code: Volume 1 West Edition. United Printing Services, New Haven. 262 p.

Gould, S. W. 1972. Geo-Code: Volume 2 East Edition. United Printing Services, New Haven. 348 p.

Kaya, H. K. and J. F. Anderson. 1972. Parasitism of elm spanworm eggs by *Ooencyrtus clisiocampae* in Connecticut. Environ. Entomol. 1:523-24.

Kaya, H. K. and J. F. Anderson. 1974. Collapse of the elm spanworm outbreak in Connecticut: The role of *Ooencyrtus* sp. Environ. Entomol. 3: 659-63.

Kegg, J. D. 1971. The impact of the gypsy moth: Repeated defoliation of oak in New Jersey. J. For. 69: 852-54.

Leonard, D.E. 1971. Air-borne dispersal of larvae of the gypsy moth and its influence on concepts of control. J. Econ. Entomol. 64: 638-41.

Lund, H. O. 1965. Mass flights of the elm spanworm moth, *Ennomos subsignarius* (Hübner), in the southeastern United States. Proc. Entomol. Soc. Wash. 67: 234-37.

Minott, C. W. 1922. The gipsy moth on cranberry bogs. USDA Bull. 1093: 1-19.

Stephens, G. R. 1971. The relation of insect defoliation to mortality in Connecticut forests. Conn. Agr. Expt. Sta. Bull. 723: 1-16.

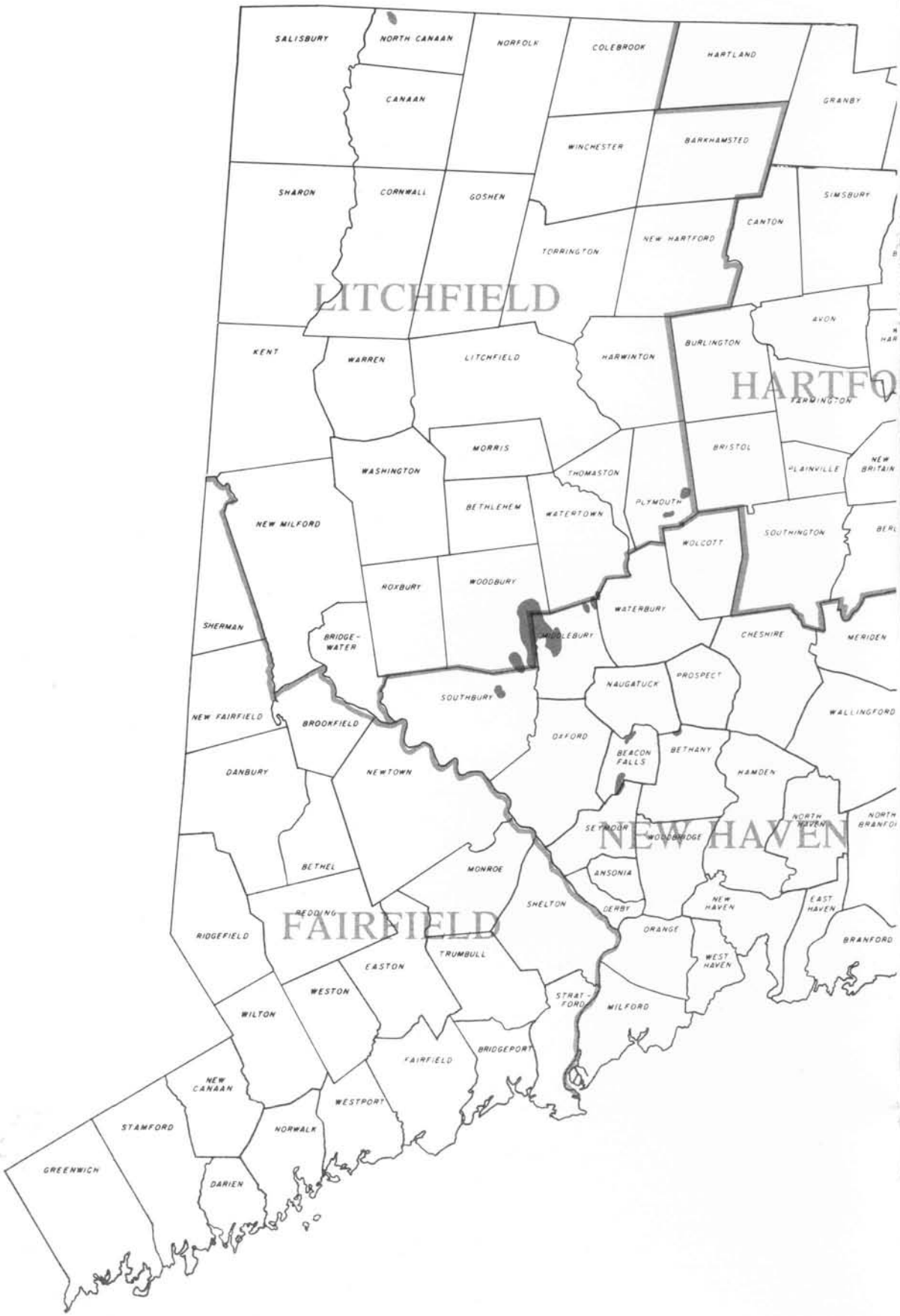
Taylor, J. and C. H. Tsao. 1962. The elm spanworm in Georgia apple orchards. Ga. Agr. Res. 3(3): 3,4.

Turner, N. 1963a. The gypsy moth problem. Conn. Agr. Expt. Sta. Bull. 655: 1-36.

Turner, N. (ed.) 1963b. Effect of defoliation by the gypsy moth. Conn. Agr. Expt. Sta. Bull. 658: 1-30.

# About the maps

The following maps show the location and the intensity of defoliation experienced in Connecticut during 1969-74. Although Table 10 shows four categories of defoliation, the 10-25% and 26-50% categories have been combined on the maps for this period. The maps for 1969 and 1970 show defoliation of 10% or more, and can be compared only with all three shades of green used on the other maps.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LITCHFIELD
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BRISTOL
PLAINVILLE
NEW BRITAIN
WASHINGTON
THOMASTON
BETHLEHEM
WATERTOWN
PLYMOUTH
NEW MILFORD
WOLCOTT
SOUTHINGTON
ROXBURY
WOODBURY
WATERBURY
SHERMAN
BRIDGE-WATER
MIDDLEBURY
CHESHIRE
MERIDEN
NAUGATUCK
PROSPECT
SOUTHBURY
NEW FAIRFIELD
BROOKFIELD
WALLINGFORD
OXFORD
BEACON FALLS
BETHANY
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NEWTOWN
HAMDEN
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NORTH BRANFO
SEYMOUR
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ORANGE
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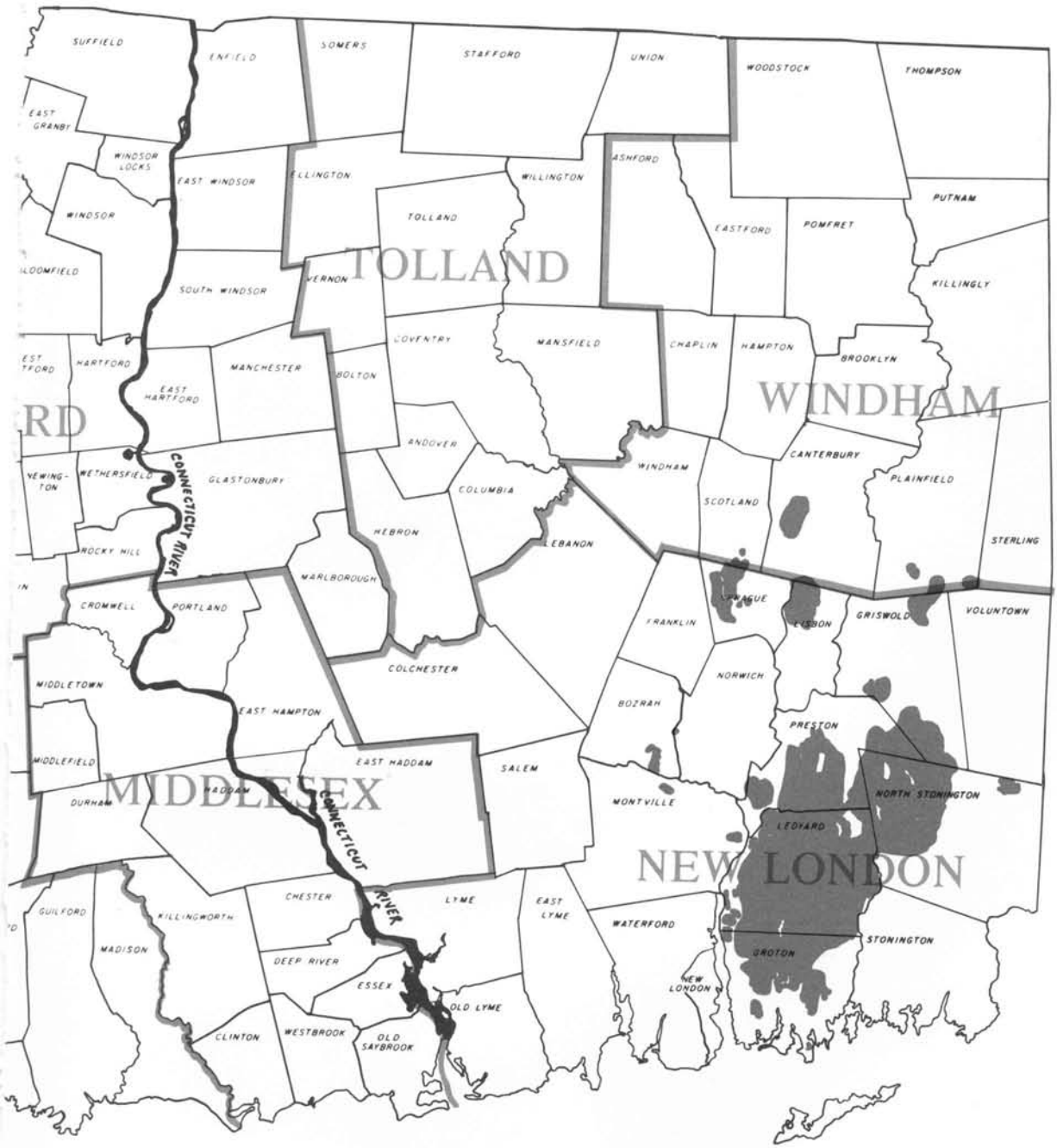
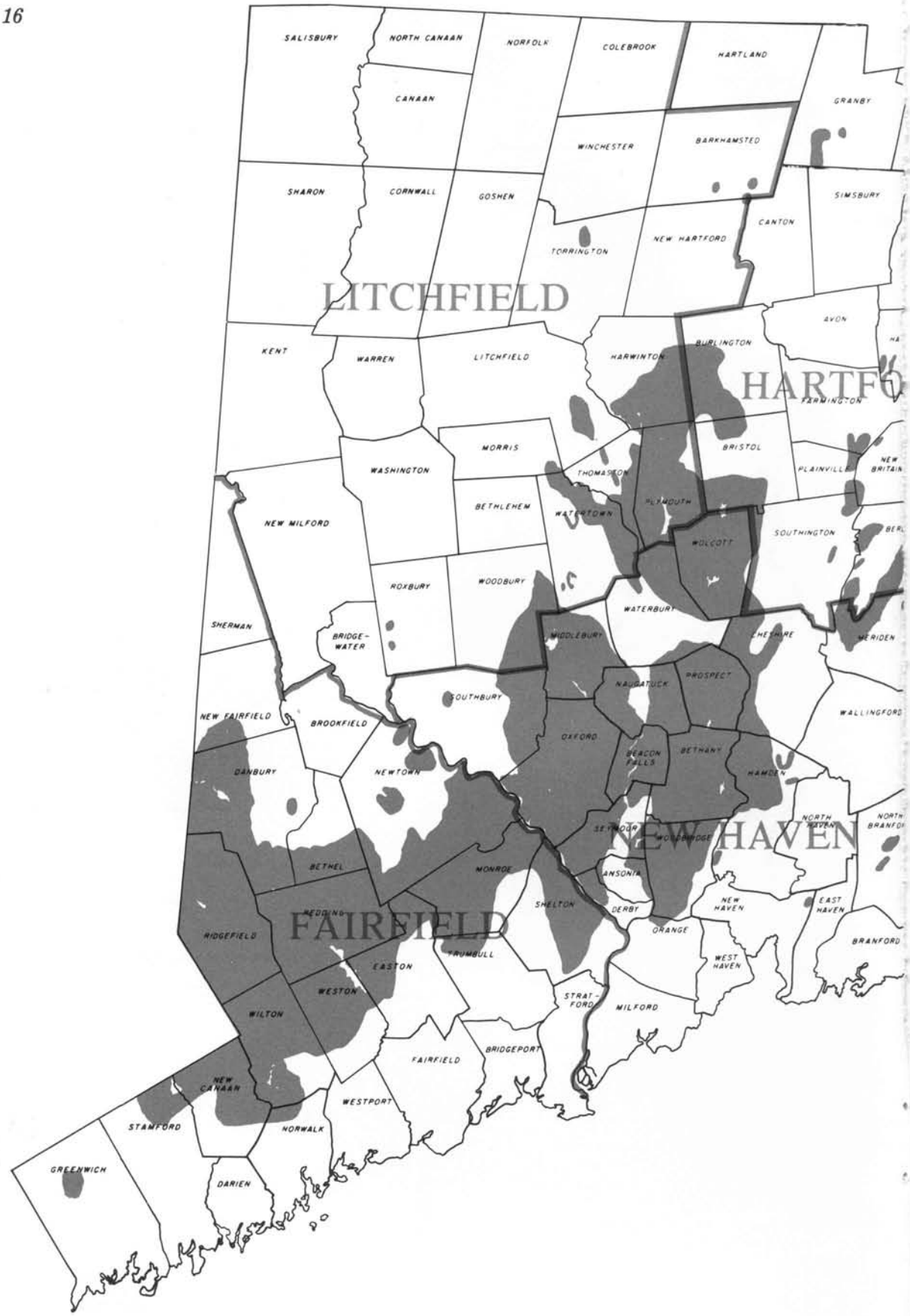



**Fig. 1 Defoliation, 1969**

10 - 100%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BRISTOL
PLAINVILLE
WASHINGTON
THOMASTON
BETHLEHEM
WATERTOWN
PLYMOUTH
NEW MILFORD
WOLCOTT
SOUTHINGTON
ROXBURY
WOODBURY
WATERBURY
SHERMAN
BRIDGE-WATER
MIDDLEBURY
CHESHIRE
MERIDEN
NAUGATUCK
PROSPECT
SOUTHBURY
WALLINGFORD
NEW FAIRFIELD
BROOKFIELD
OXFORD
BEACON FALLS
BETHANY
DANBURY
NEWTOWN
HAMDEN
NORTH HAVEN
NEW HAVEN
BETHEL
MONROE
ANSONIA
SHELTON
DERBY
NEW HAVEN
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REDDING
FAIRFIELD
RIDGEFIELD
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WEST HAVEN
WESTON
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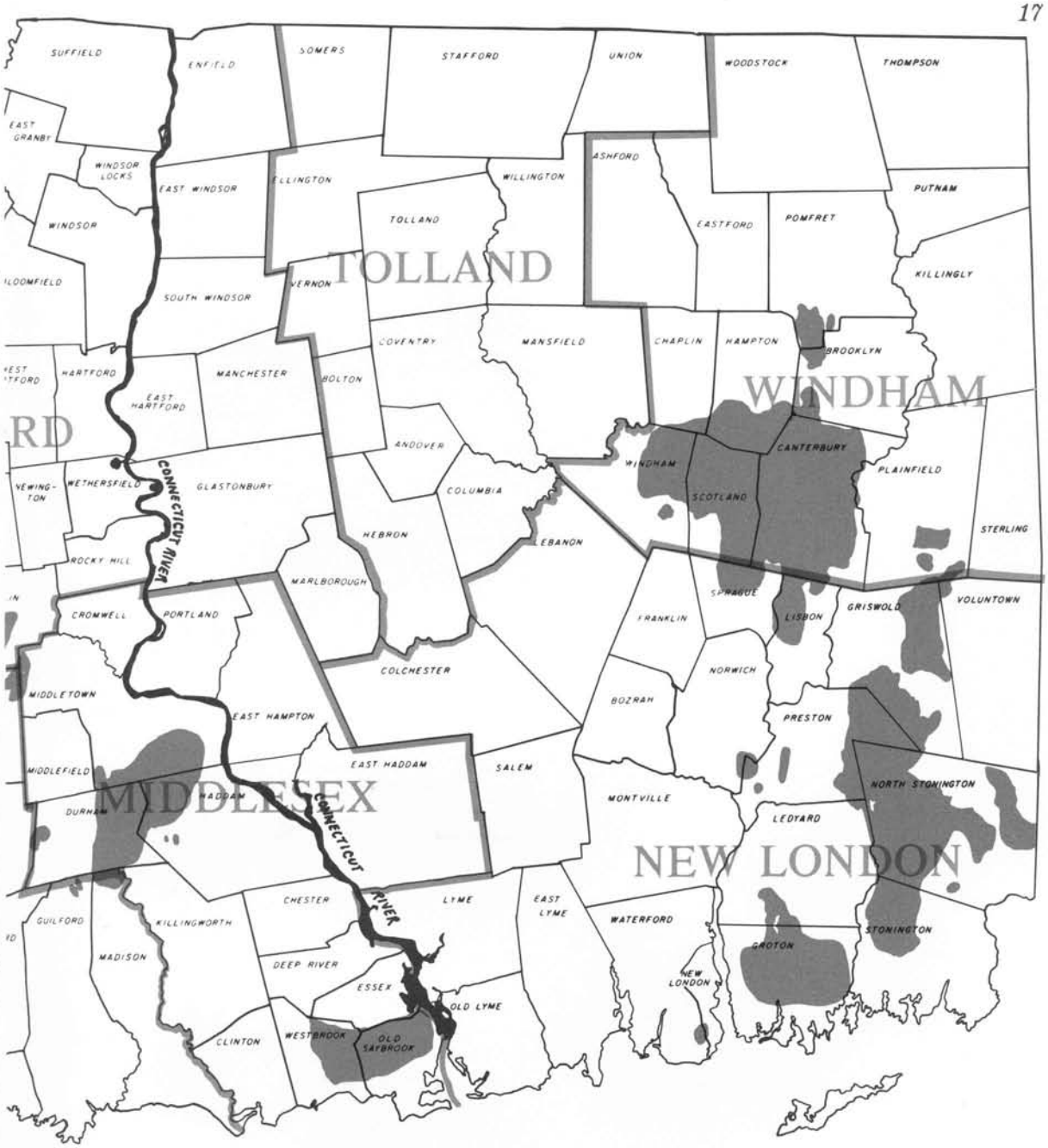
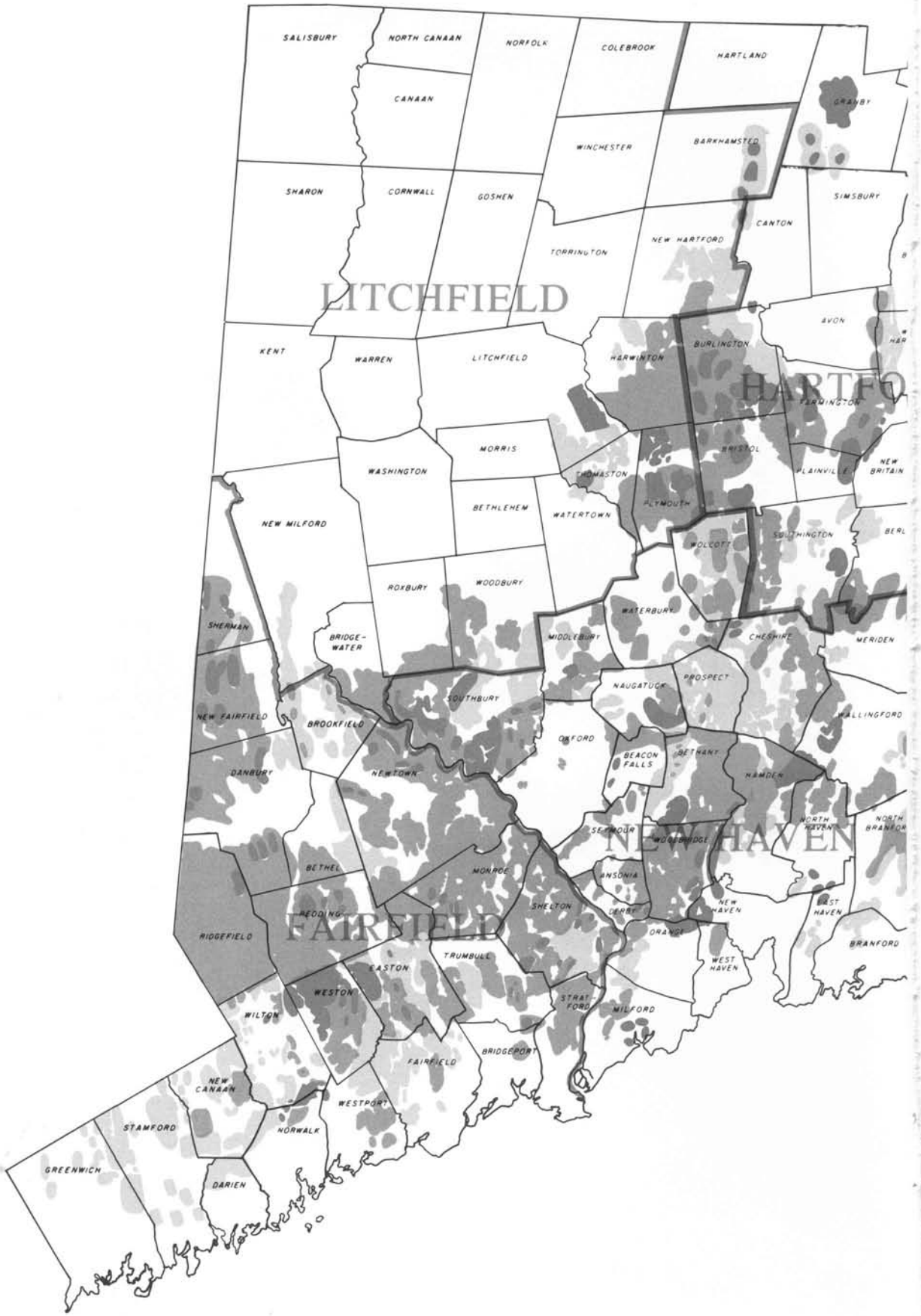



**Fig. 2 Defoliation, 1970**

10 - 100%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MERIDEN
NAUGATUCK
PROSPECT
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NEW FAIRFIELD
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DARIEN

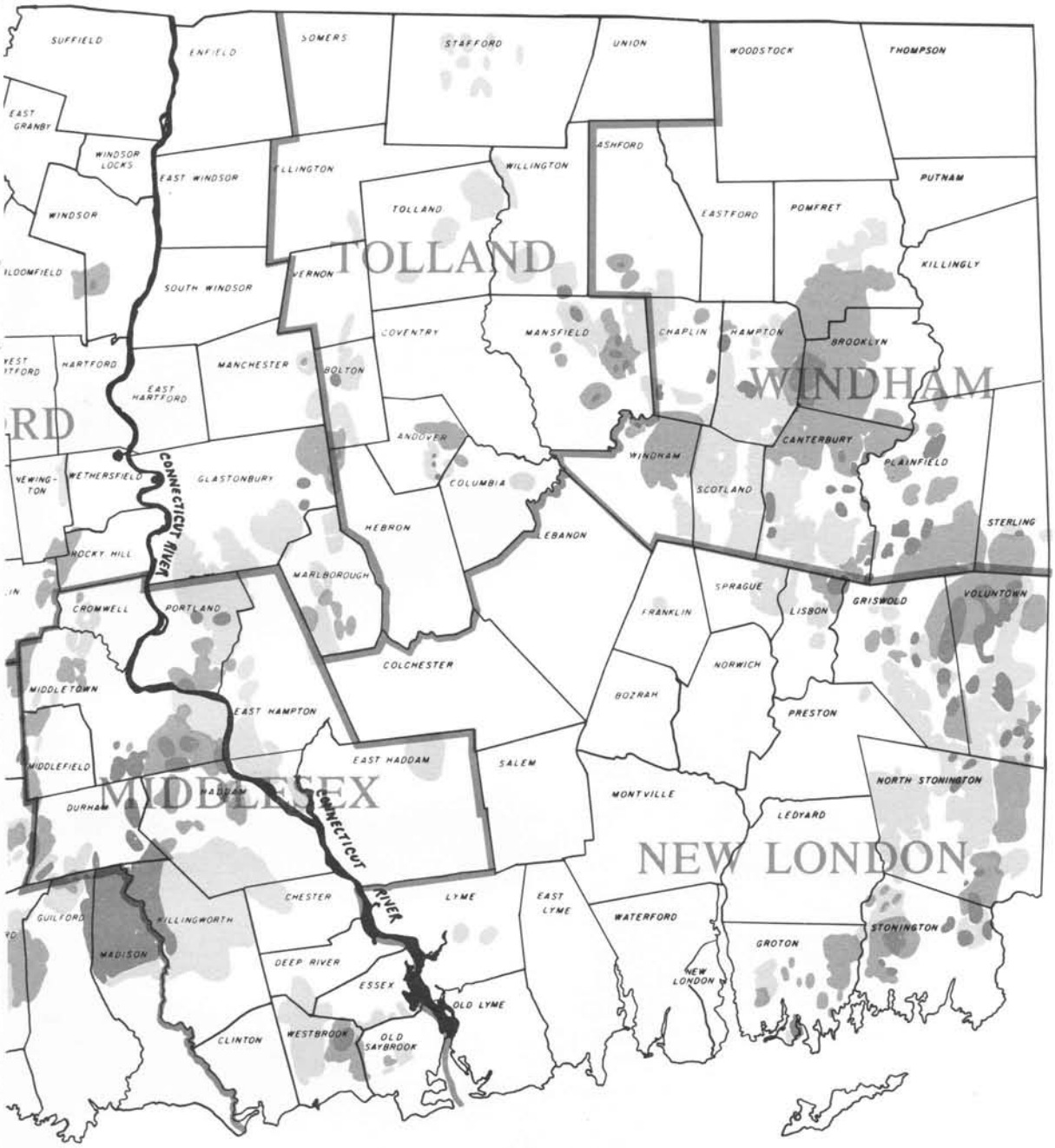
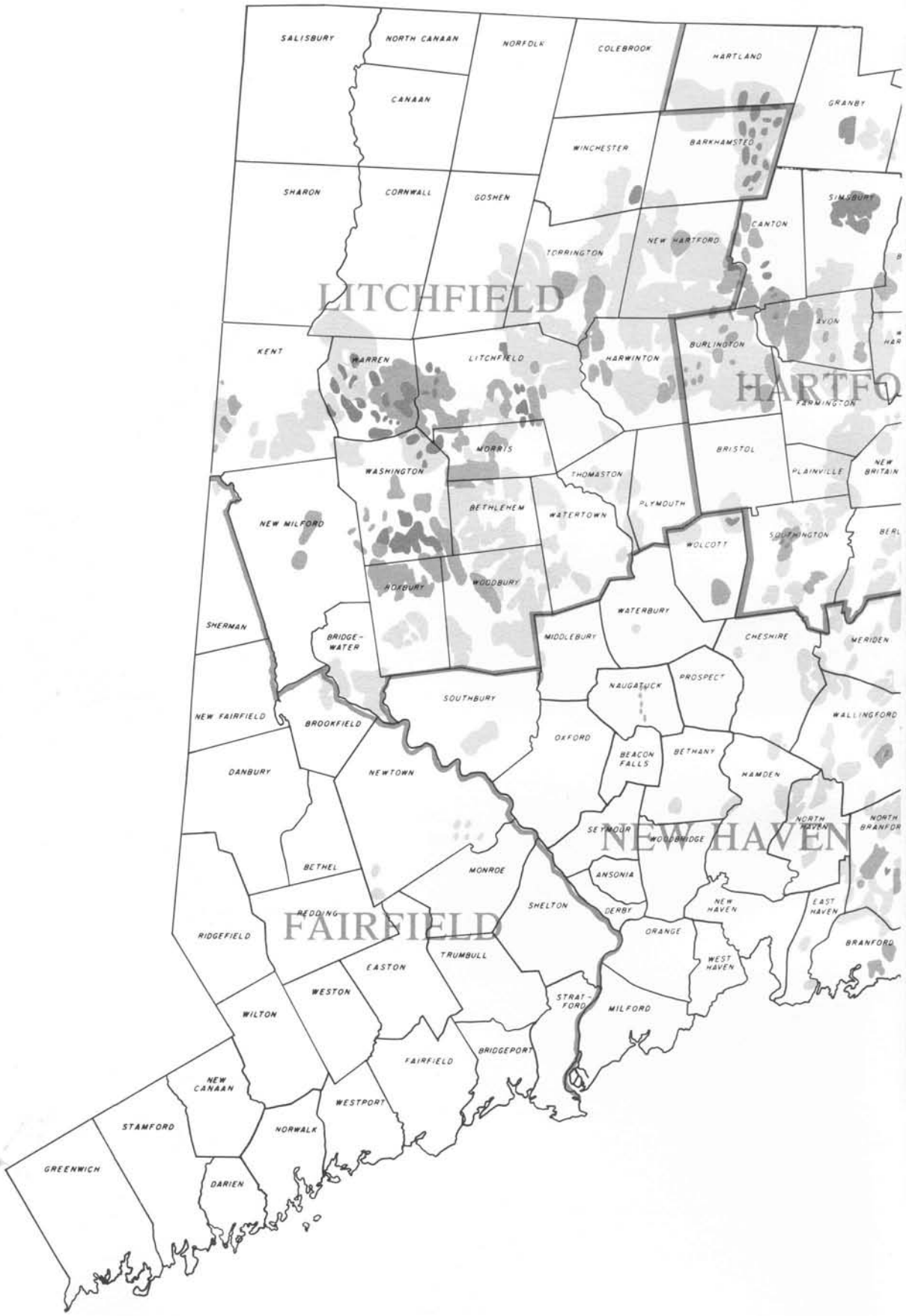



**Fig. 3 Defoliation, 1971**

10 - 50%

51 - 75%

76 - 100%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GOSHEN
SIMSBURY
CANTON
TORRINGTON
NEW HARTFORD
LITCHFIELD
AVON
KENT
WARREN
LITCHFIELD
HARWINTON
BURLINGTON
HARTFO
FARMINGTON
MORRIS
BRISTOL
WASHINGTON
THOMASTON
PLAINVILLE
NEW BRITAIN
NEW MILFORD
BETHLEHEM
WATERTOWN
PLYMOUTH
WOLCOTT
SOUTHINGTON
BERL
ROXBURY
WOODBURY
SHERMAN
BRIDGE-WATER
MIDDLEBURY
WATERBURY
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MERIDEN
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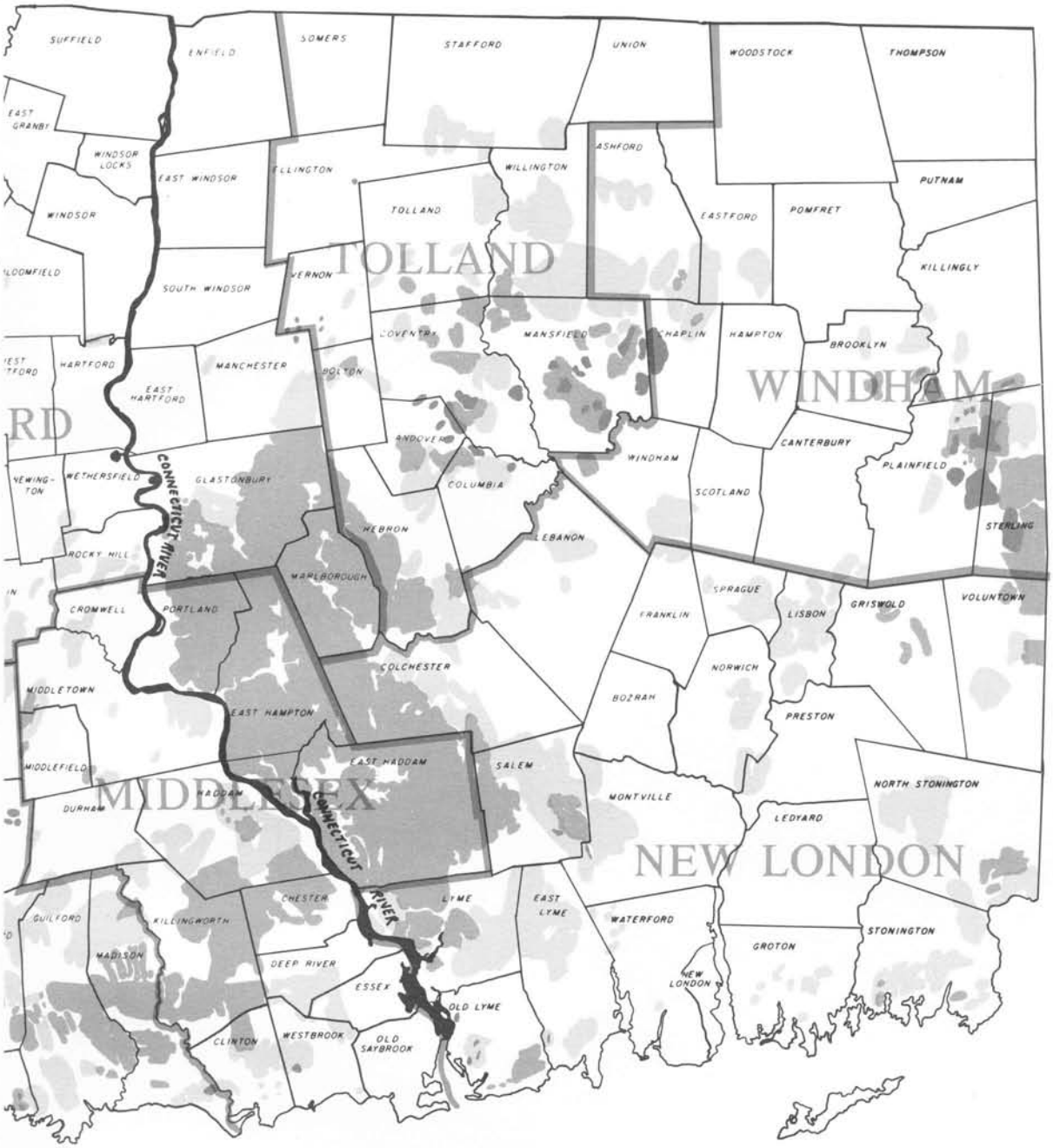
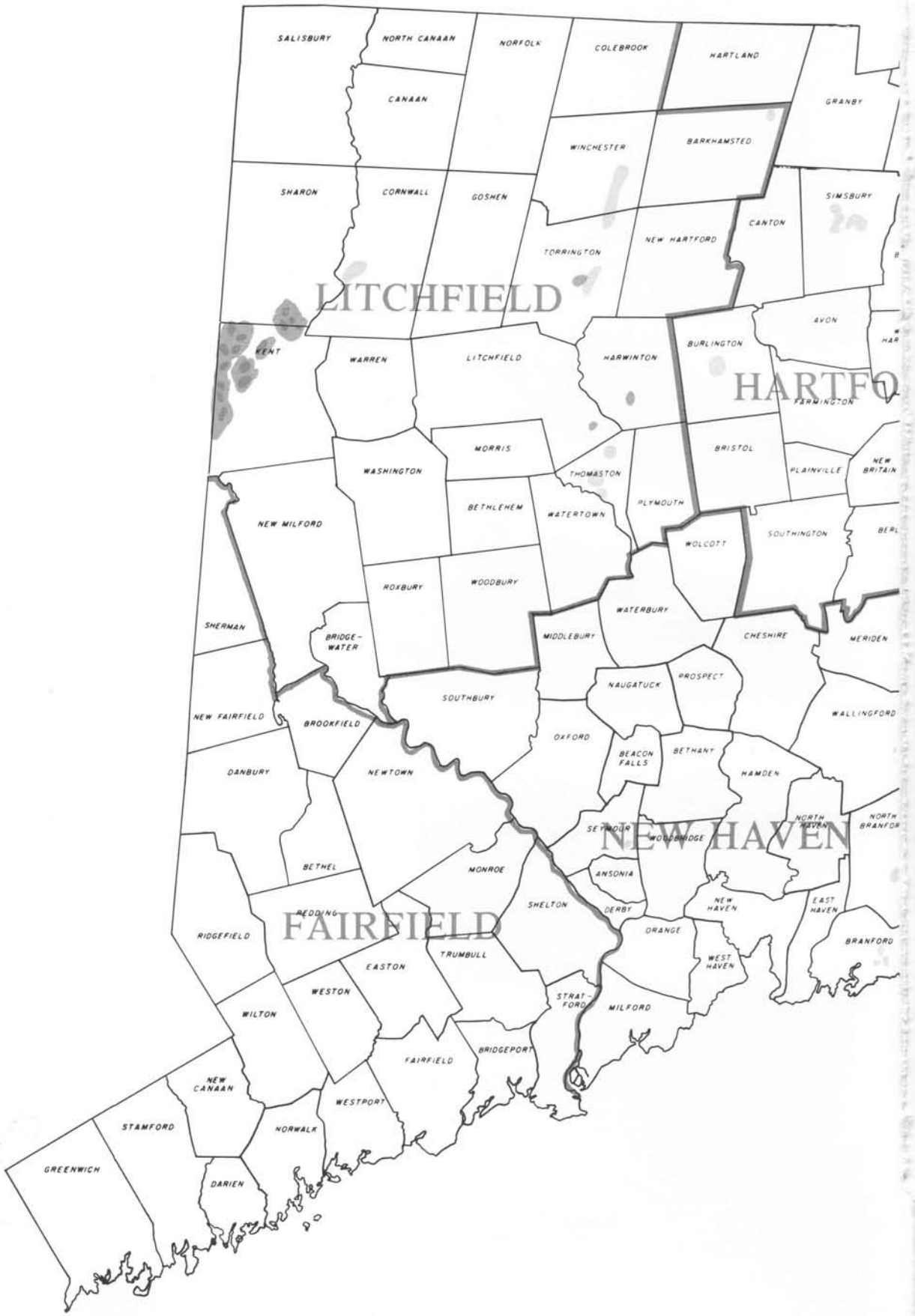



**Fig. 4 Defoliation, 1972**

10 - 50%

51 - 75%

76 - 100%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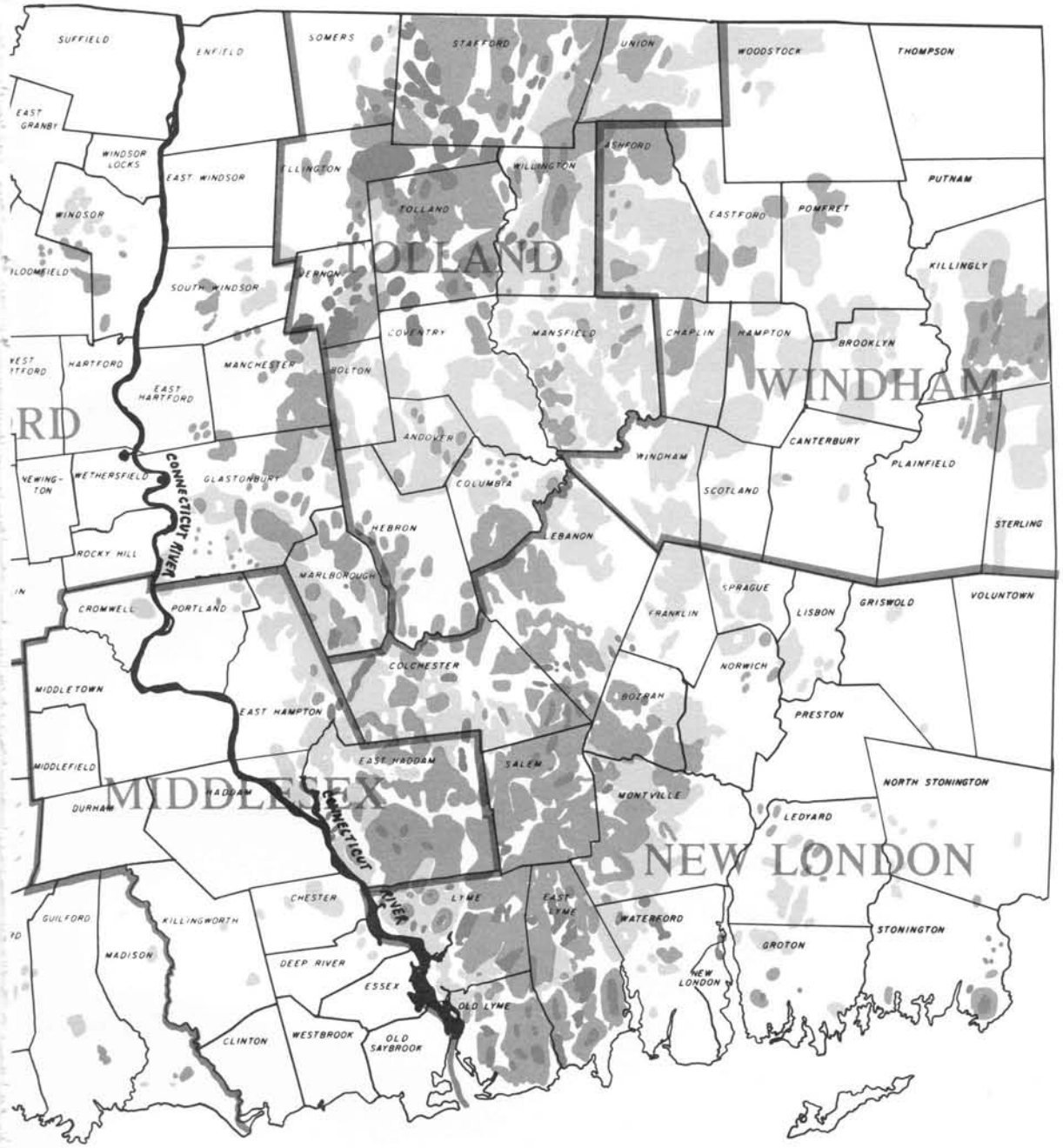
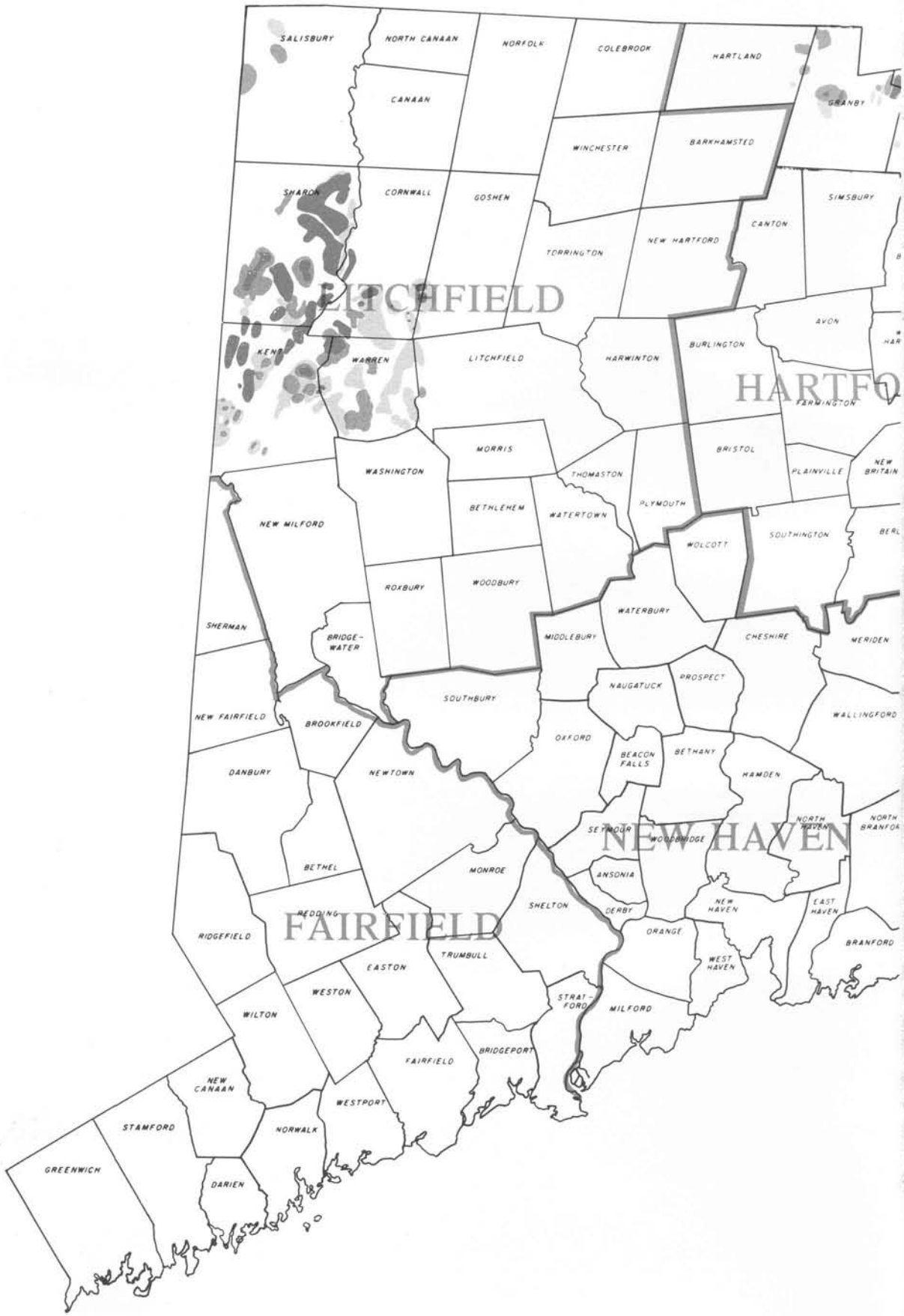



**Fig. 5 Defoliation, 1973**

10 - 50%

51 - 75%

76 - 100%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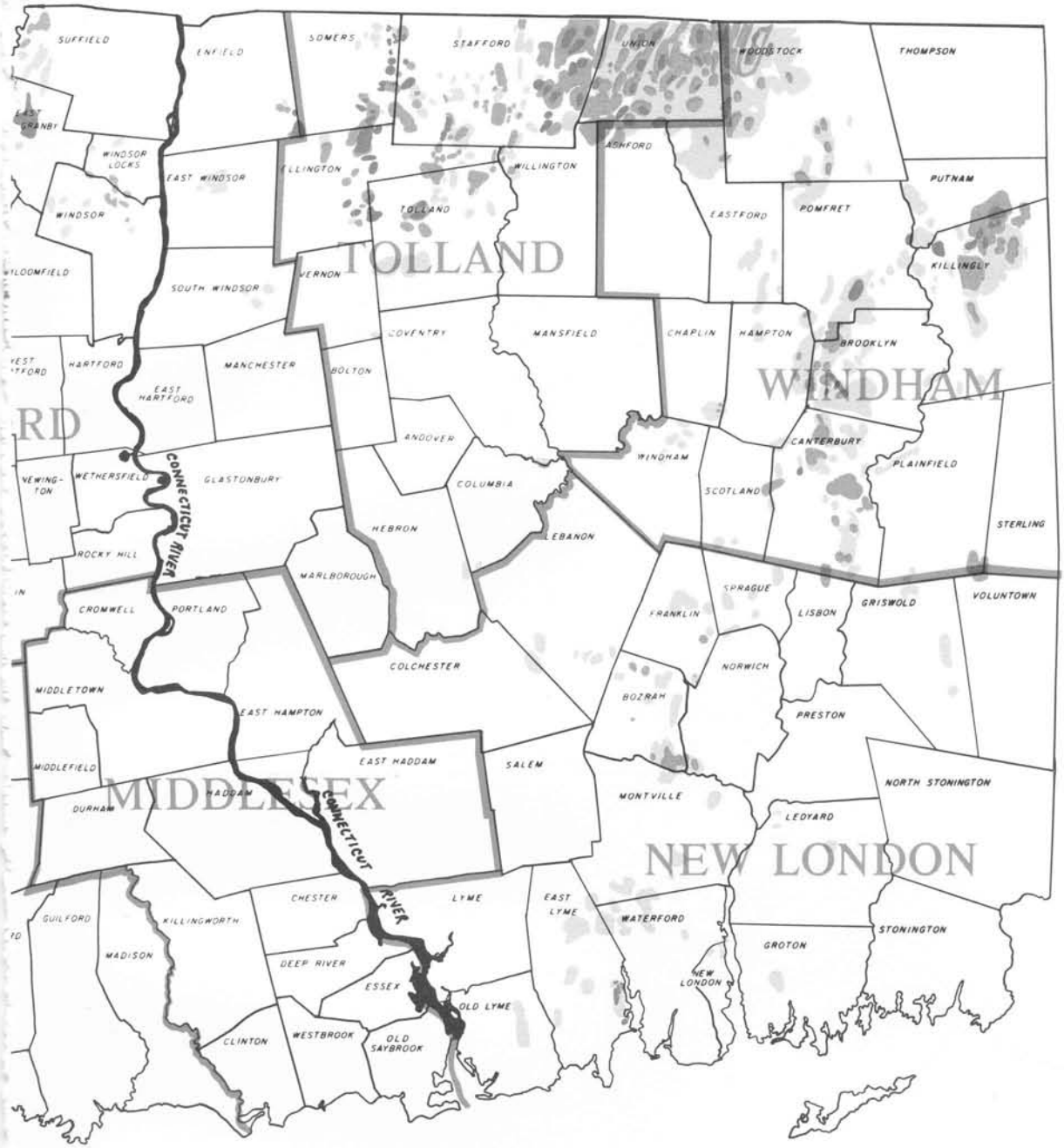


**Fig. 6 Defoliation, 1974**

10 - 50%

51 - 75%

76 - 100%