1992 Gypsy Moth Programs in the Southeast[1]

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ABSTRACT The gypsy moth, *Lymantria dispar* (L.), has been one of the most destructive hardwood forest insect pests in the northeastern U.S. since it was accidentally introduced in the late 1860's. The U. S. range of the insect has expanded annually by a few kilometers through natural spread. However, gypsy moth range expansion has been greatly mitigated by accidental transport of life stages on recreational and commercial vehicles and on outdoor household articles. They gypsy moth is one of two forest insects that are under Federal Domestic Quarantine enacted in 1912. Since the late 1800's Federal, State, and local governments have worked cooperatively in trying to eradicate, suppress, and/or control gypsy moth populations. Thousands of worker-hours and millions of dollars are expended annually on these cooperative projects. Although the goals of these projects are developed and implemented cooperatively, comprehensive summarizations of these efforts are limited. This study was designed to summarize and document the results of the 1992 cooperative gypsy moth survey projects in eight states that comprise the USDA-APHIS-PPQ southeastern region.

KEY WORDS *Lymantria dispar,* pheromone trapping, regulatory, CAPS Program, NAPIS, APHIS PPQ.

The gypsy moth, *Lymantria dispar* L., (Family Lymantriidae) is one of the most serious hardwood pests in the Eastern U. S. Gypsy moth caterpillars feed on more than 300 species of trees and shrubs, with oaks being preferred hosts. The insect is native to temperate regions of Europe, southern Asia and Africa (Coulson and Witter 1984, Leonard 1981). Defoliation caused by this insect may result in tree mortality or weaken trees making them more susceptible to mortality caused by secondary disease organisms, insects, and drought. In heavily infested urban and recreational areas, gypsy moth can be a serious pest of ornamental plants and landscapes.

In North America only the male gypsy moth is capable of flight; the females are heavy-bodied and flightless. In contrast, the Asian gypsy moth males and females are flighted. Gypsy moths are univoltine and overwinter as eggs, which the female moth lays in buff-colored masses of 75 to 1,000 eggs in sheltered locations. Normal annual spread of a few feet to several kilometers occurs when small larvae move to

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branch terminals, extrude a strand of silk, and are picked up and transported by wind currents. Long distance spread occurs as a result of egg masses, pupae, or larvae being transported from infested areas to uninfested areas by people (Leonard 1981, Elkinton and Leibhold 1990, McManus et. al 1989).

The gypsy moth was introduced into the U.S. in 1868 or 1869 by Leopold Trouvelot, a French naturalist, who had hopes of interbreeding the moth with native silkworms to produce better silk products (Forbush and Fernald 1896). The first recorded outbreak occurred in 1889. In 1981, a record 5.2 million hectares (12.9 million acres) were defoliated (McManus et. al 1989). The gypsy moth is now established throughout the Northeast and has spread south into Virginia, northeastern North Carolina, and West Virginia, and west into Michigan and Ohio. Seventeen states, either entirely or in part, are now considered to be generally infested by gypsy moth (FR 1993). Isolated infestations have occurred in several other U. S. locations and in Canada in recent years (GMD 1993).

The gypsy moth can potentially infest all temperate hardwood growing areas of North America. It is one of two forest insect pests under regulation of a U. S. Department of Agriculture (USDA) Federal Domestic Quarantine (Domestic Quarantine 7CFR 301.45 Gypsy Moth) enacted in 1912 [The other being the browntail moth *Euproctis chrysorrhoea* (L.)]. Agencies within the USDA have the responsibility of dealing with and coordinating all U. S. gypsy moth programs. The Animal Plant Health Inspection Service (APHIS) is responsible for administering the regulatory aspects of the program, conducting surveys to detect and delimit isolated infestations that are remote from the generally infested area, and developing methods to eradicate isolated infestations. APHIS also assists States with projects to eradicate small isolated infestations on private land. Gypsy moth research is conducted by the Agricultural Research Service (ARS), the Cooperative State Research Service (CSRS), and the Forest Service (FS). The Cooperative Extension Service (CES) coordinates education programs and disseminates information about gypsy moth. The role of the FS, in addition to conducting research, is in gypsy moth survey and control within the generally infested area, either directly on Federal lands or cooperatively with States on non-Federal lands. The FS is also involved in eradicating isolated infestations on or contiguous to Federal lands and large isolated infestations on non-Federal lands. Additionally, USDA APHIS, Plant Protection and Quarantine (PPQ) has the responsibility of coordinating, with the appropriate state agencies, a national trapping program to detect isolated gypsy moth infestations (DR 1990, PDC 1994).

Since the late 1800's, federal, state and local governments have worked cooperatively to eradicate, suppress, and control GM populations. As part of the cooperative survey and detection projects, approximately 250,000 pheromone traps are operated annually to monitor gypsy moth populations (Ravlin et al. 1987). Several states have developed various levels of computerization of their data. Most notable among eastern states are Virginia and Michigan (Fleisher et al. 1990, Gage et al. 1990, Roberts et al. 1993). The Forest Service has developed gypsy moth information projects principally dealing with research aspects of the overall program (Hutchinson and DeLost 1993, Spears et al. 1991). However, these projects have not addressed the data needs from a multistate, broad-based summary approach. In recent years, data generated by pheromone

trap surveys have been entered by cooperators of the USDA-APHIS-PPQ sponsored Cooperative Agricultural Pest Survey (CAPS) Program into the National Agricultural Pest Information System (NAPIS) database (CAPS 1992). However, there was still a need for information on other aspects of state-level GM projects that is not and will not be contained within NAPIS. For example, expenditures for Survey and Detection, Delimiting Surveys, control programs, and larval surveys. Additionally, the GM data contained in the NAPIS database had not been closely scrutinized and checked for completeness, nor had multistate summarization of program data been developed. In response to these needs, we initiated an extensive project in 1992 to develop the needed data sets, closely monitor and coordinate necessary corrections, and generate summary reports. A written questionnaire also was developed and distributed to appropriate personnel in each of the cooperating states to obtain necessary information not contained in NAPIS. Each respective State CAPS Coordinator was involved in the oversight of the questionnaire process within his/her state.

This paper summarizes 1992 GM project data from the southeastern states of Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina and Tennessee that comprise the USDA-APHIS-PPQ Southeastern Region (SER).

Materials and Methods

Terminology used in this paper conforms to PPQ definitions (PDC 1994). Definitions worthy of special note include:

Trap site - is the physical location that an individual trap is placed, not a physical trap which may be removed and replaced during the season. The trap site applies for the duration of the trapping season.

Positive trap - is a trap site that captured at least one male gypsy moth.

Single capture - Only one moth was captured at that trap site.
Multiple capture - More than one moth was captured at that trap site.

Detection survey - Pheromone traps are used to determine where isolated infestations of gypsy moth occur and where further delimiting may be necessary. The number of traps used per square kilometer varies between 0.6 and 2.6 (0.25 - 1.0 per sq. mi.), depending upon the potential risk of gypsy moth introduction in the area to be surveyed. Suggested trapping frequency varies from at least every 2 years to as infrequently as every 4 years.

Delimiting survey – Pheromone traps are used to determine if an infestation is present and, if present, the approximate size of the infestation. Delimiting surveys are generally conducted the year following positive multiple moth captures. The number of traps per square kilometer varies between 41.4 and 93.2 (16 to 36 per sq. mi.).

Mass trapping – is a behavioral trapping method that can be used for eradicating low population densities. By attracting males, the traps reduce the number of males that are available for mating. The concept is to capture virtually every male in an area, thereby preventing successful mating of all females. Mass trapping involves an aggressive trapping grid of 1.2 to 4.1 traps per hectare (3 - 10 per acre).

Pheromone Trapping Summaries. Extensive gypsy moth pheromone trap surveys based upon PPQ guidelines using the triangular shaped "delta" style or the milk carton traps were conducted by several agencies across the PPQ SER. All traps were baited with (+)-disparlure dispenser female sex pheromone; consequently, only males are attracted to and are captured in traps. Refer to the PPQ Gypsy Moth Program Manual (PDC 1994) for specifics of trap configuration, setup, and operation.

Cooperators provided data from trapping surveys to the appropriate CAPS State Survey office where they were summarized, converted to the proper data entry format and transmitted to NAPIS.

Gypsy moth survey report data used in this study were, in most cases, retrieved from NAPIS. NAPIS records are annual, county-level summary records for each type of survey and/or agency that conducted the survey. Consequently, the database frequency contains multiple records for a county on any given year. The data elements contained in each data record pertinent to this study include:

(1) year, state, and county,
(2) type of survey conducted,
(3) the survey method used (eg. type of trap, visual, etc.),
(4) the agency/group that conducted the survey (PPQ, State Dept. Agriculture, FS, etc.),
(5) total number of traps (sites) operated,
(6) total number of male moths captured,
(7) number of positive traps, and
(8) number of multiple capture traps (PDC 1994).

Inconsistencies and errors identified during the retrieval and summarization process by the authors were reported to the appropriate personnel in each state for subsequent correction. Information on gypsy moth programs other than trap report data was obtained from responses of regulatory and CAPS program personnel in cooperating states to the mailout questionnaire. This questionnaire requested information on:

(1) larval trapping,
(2) egg mass survey,
(3) agencies participating,
(4) known infestations,
(5) number and description of any regulatory incidents,
(6) pesticide applications, and
(7) estimates for "Survey and Detection," "Delimiting Surveys," and "Control" program activity costs.

A copy of the questionnaire is available from the senior author.

Data records retrieved from NAPIS or created from responses to the written questionnaire were entered into and processed on a PC-compatible 486 microcomputer using Paradox 4.0 Relational Database (Borland International, Scotts Valley, CA). Maps were produced from summarized data imported into Atlas Pro (Version 1.2) Geographic Data Analysis and Presentation System (Strategic Mapping Inc., San Jose, CA).

Results and Discussion

Pheromone Trap Surveys. In 1992, over 72,000 trap sites were operated and monitored for gypsy moth in 588 counties in the eight southeastern states. Regionwide, 79% of the trap sites used the delta style gypsy moth trap. Forty percent of the trap sites in North Carolina (in nine northeastern counties) and 98% of the trap sites in South Carolina used milk carton traps. All other states used delta style traps exclusively.

There were 5,905 males captured in 172 counties. Gypsy moths were captured in all of the states for which data are provided. North Carolina captured 94.9% (15,078) of the total moths in the region. Seventy-two out of 100 North Carolina counties reported positive captures.

Over 13,600 of the moths captured in North Carolina were trapped in 16 northeastern and north central counties. Thirty-nine North Carolina counties had one or more multiple capture traps. Excluding North Carolina, 84 trap sites in the region reported having captured more than one GM.

Table 1 presents summaries of the 1992 pheromone trapping projects for each of these states. Figure 1 provides a comparison, by state, of the number of trapping sites monitored in 1992. Figure 2 provides a summarization of the number of males captured in each trapping project.

Figure 3 summarizes the overall regional gypsy moth program trapping results. By design and according to PPQ guidelines, not all counties in all states were trapped in 1992. Figure 4 displays only the results of the detection surveys that are the coarse trap grids designed to detect the occurrence of introductions. Detection surveys are pre-empted by delimitation surveys in areas suspected to contain infestations. Consequently, differences occur between Figures 3 and 4, principally in Georgia, North Carolina, and Tennessee where certain counties are either excluded (North Carolina and Tennessee) or are indicated as single captures (Georgia, North Carolina, and Tennessee) rather than multiple captures. Figure 5 shows the scope and geographic distribution of counties where delimiting surveys were implemented. In most cases, the delimiting surveys were conducted after positive, multiple moth captures occurred at a detection trap location in previous years. Figure 6 identifies the counties and outcome of all mass trapping surveys in the cooperating states.

Additional Program Information (Obtained from questionnaire responses). Larval surveys were conducted in Florida, Georgia, North Carolina and Tennessee. In the SER PPQ region, approximately 515 larval band traps were operated in 17 counties during 1992. Egg mass surveys were conducted in Georgia (1 site), North Carolina (34 counties), South Carolina (1 site) and Tennessee (5 counties).

Table 1. Summary of 1992 gypsy moth pheromone trapping surveys in the eight states that comprise the southeastern PPQ region. Data are summarized by type of survey and agency that conducted the survey within each state.

State	Type of Survey	Agency	No. of Counties Surveyed*	No. of of Trap Sites	No. of Counties with Captures*	No. of Positive Trap Sites**	No of Individuals Captured	No. of Single-Capture Trap Sites†	No. of Multiple-Capture Trap Sites‡
ALABAMA									
	Delimiting	State/Federal	**5**	315	**2**	2	2	2	0
	Detection	U.S. Forest Service	**2**	9	**0**	0	0	0	0
	Detection	State/Federal	**67**	8502	**10**	16	28	11	5
		Subtotal	**67**	8511	**10**	16	28	11	5
	State Total		**67**	**8826**	**12**	**18**	**30**	**13**	**5**
FLORIDA									
	Delimiting	State/Federal	**2**	32	**0**	0	0	0	0
	Detection	State/Federal	**55**	3095	**30**	112	176	81	31
	State Total		**55**	**3127**	**30**	**112**	**176**	**81**	**31**
GEORGIA									
	Delimiting	State Forestry	**2**	765	**2**	33	59	22	11
	Mass Trapping	State Forestry	**1**	243	**1**	16	32	12	4
	Detection	U. S. Forest Service	**41**	272	**1**	1	1	1	0
	Detection	State Forestry	**82**	9729	**9**	19	22	16	3
		Subtotal	**99**	10001	**10**	20	23	17	3
	State Total		**99**	**11009**	**11**	**69**	**114**	**51**	**18**
KENTUCKY									
	Delimiting	USDA-APHIS	**3**	77	**3**	8	9	7	1
	Delimiting	State /Federal	**1**	25	**1**	1	1	1	0
		Subtotal	**4**	102	**4**	9	10	8	1
	Detection	USDA-APHIS	**3**	165	**0**	0	0	0	0
	Detection	State/Federal	**45**	4760	**6**	6	6	6	0
		Subtotal	**48**	4925	**6**	6	6	6	0
	State Total		**51**	**5027**	**10**	**15**	**16**	**14**	**1**

Table 1. Continued.

State	Type of Survey	Agency	No. of Counties Surveyed*	No. of of Trap Sites	No. of Counties with Captures*	No. of Positive Trap Sites**	No of Individuals Captured	No. of Single-Capture Trap Sites†	No. of Multiple-Capture Trap Sites‡
MISSISSIPPI									
	Detection	USDA-APHIS	**45**	3492	**4**	6	13	4	2
	Detection	State Ag. Dept.	**38**	2952	**1**	1	1	1	0
	State Total		**82**	**6444**	**5**	**7**	**14**	**5**	**2**
NORTH CAROLINA									
	Delimiting	State/Federal	**9**	9733	**9**	2660	5545	1402	1258
	Mass Trapping	State Ag. Dept.	**24**	3459	**16**	546	6309	173	373
	Detection	State/Federal	**93**	11327	**64**	1530	3224	882	648
	State Total		**100**	**24519**	**72**	**4736**	**15078**	**2457**	**2279**
SOUTH CAROLINA									
	Delimiting	USDA-APHIS	**10**	1756	**1**	20	107	13	7
	Detection	USDA-APHIS	**46**	3597	**14**	31	137	27	4
	Detection	U. S. Forest Service	**20**	128	**1**	1	1	1	0
		Subtotal	**46**	3725	**14**	32	138	28	4
	State Total		**46**	**5481**	**14**	**52**	**245**	**41**	**11**
TENNESSEE									
	Delimiting	State/Federal	**4**	1145	**4**	36	82	34	2
	Detection	State/Federal	**85**	6432	**15**	52	140	43	9
	State Total		**88**	**7577**	**18**	**88**	222	**77**	11
SOUTHEASTERN REGION TOTALS			**588**	**72010**	**172**	**5097**	**15895**	**2739**	**2358**

* Some counties were trapped by more than one agency and more than one survey type.

** It is assumed that the definition of "trap site" as defined in the text was used for data contained in the National Agricultural Pest Information System.

† Only a single moth was captured at one trap site during the entire trap season.

‡ More than one moth captured at one site during the entire season.

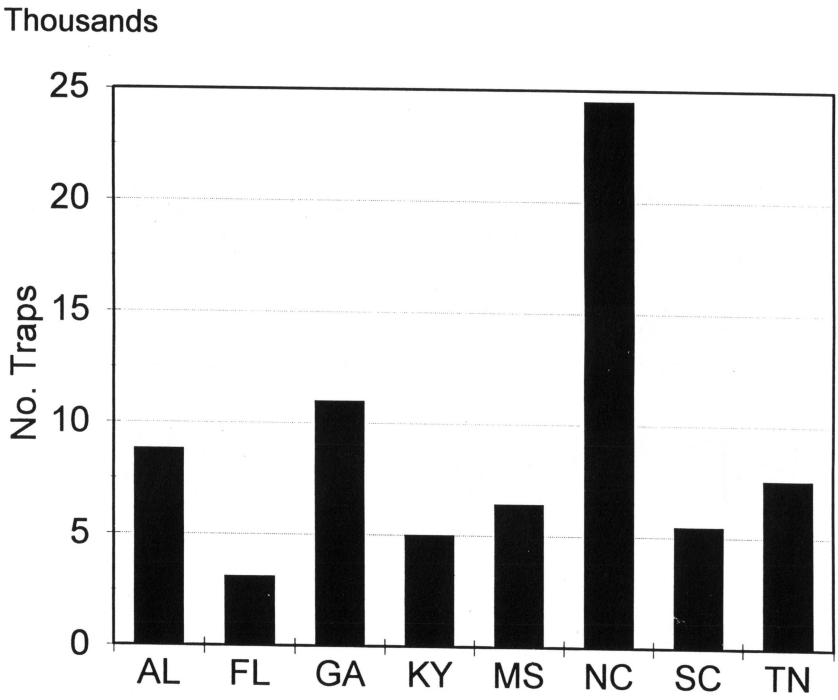

Fig. 1. Number of gypsy moth pheromone trap sites operated in 1992 by all agencies as part of the cooperative survey program in the eight states in the southeastern PPQ region.

Agencies participating in gypsy moth surveys are listed below by state. The agency(ies) that functioned as the lead agency(ies) are indicated in **boldfaced type.**

Alabama: **PPQ,** Alabama Forestry Commission and Alabama Department of Agriculture

Florida: **PPQ,** U.S. Forest Service and Florida Department of Agriculture and Consumer Service, Division of Forestry

Georgia: **Georgia Forestry Commission,** PPQ and the U.S. Forest Service

Kentucky: **PPQ,** U.S. Corp. of Engineers and U.S. Forest Service

Mississippi: **PPQ,** Mississippi Department of Agriculture and Commerce, Bureau of Plant Industry

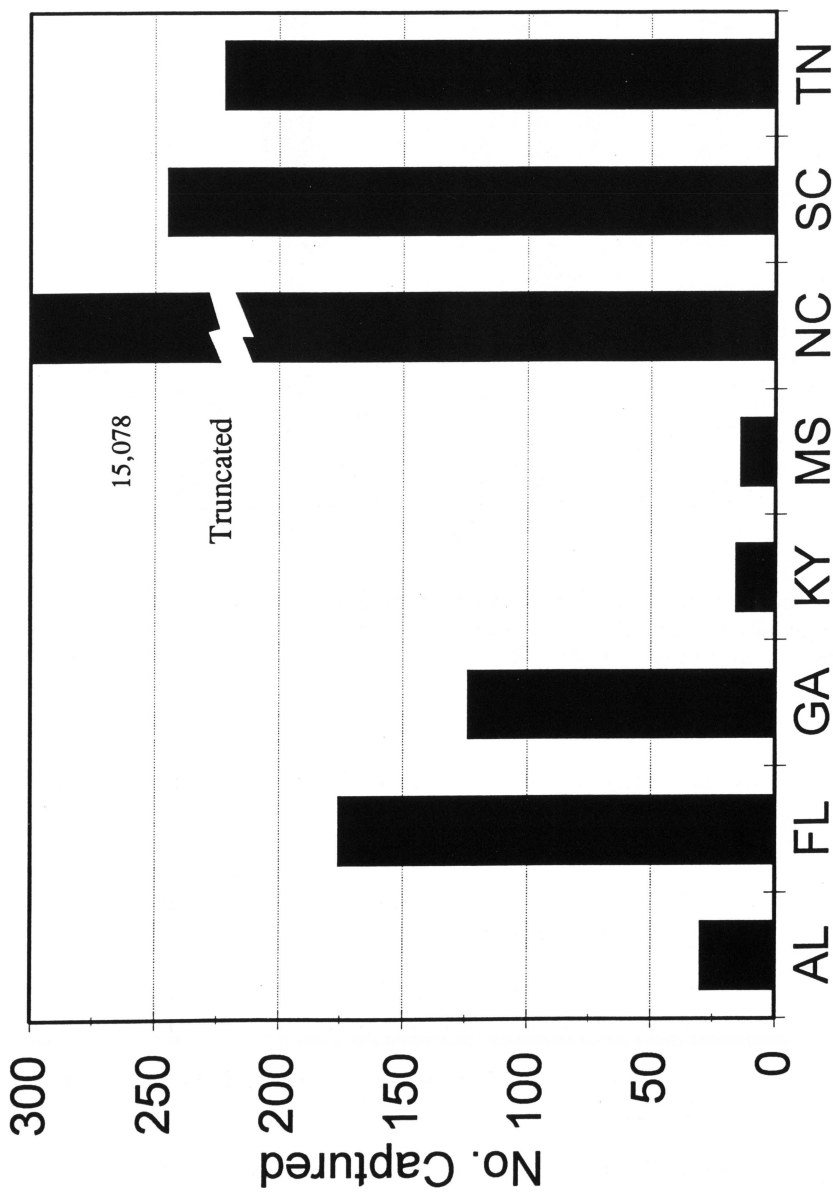

Fig. 2. Number of male gypsy moths captured in pheromone traps operated in 1992 as part of the cooperative survey program in the eight states in southeastern PPQ region. Data are a composite of surveys conducted by all cooperating agencies.

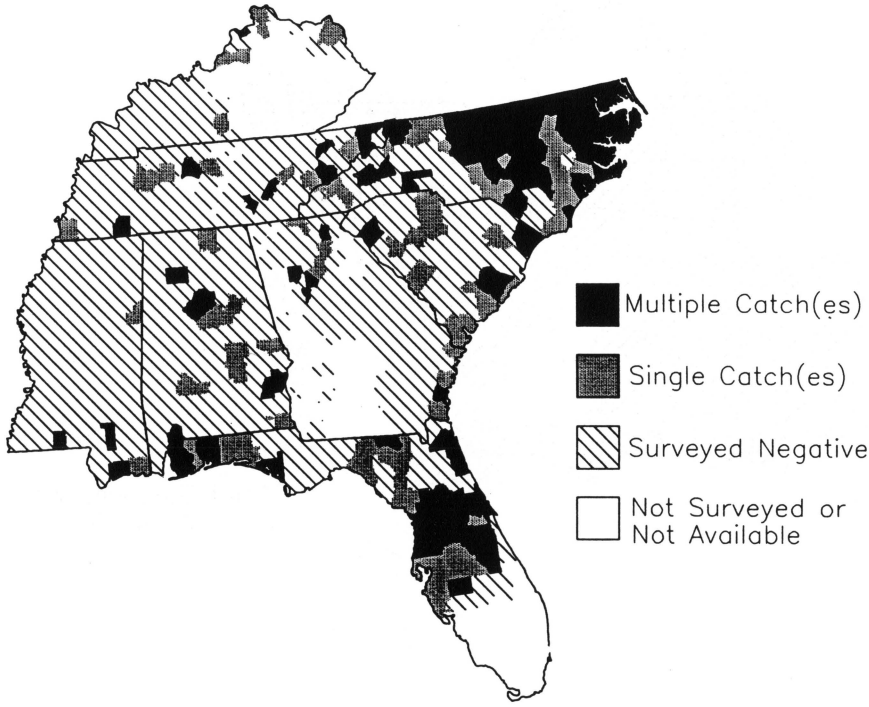

Fig. 3. Results of 1992 gypsy moth detection, delimiting and mass trapping surveys conducted in the eight states that comprise the PPQ southeastern region. Data presented are county level summarizations of all traps operated in the respective counties by all agencies.

North Carolina: **NC Department of Agriculture** (non-quarantine areas), NC Division of Forest Resources (quarantine areas), PPQ and U. S. Forest Service

South Carolina: **PPQ,** SC Department of Plant Industry and the U.S. Forest Service

Tennessee: **TN Department of Agriculture,** TN Department of Forestry, PPQ and U.S. Forest Service

Established GM infestation were reported in one Georgia, ten North Carolina, and two Tennessee counties. Quarantines were in effect in two counties in North Carolina. Regulatory incidents involving shipment of GM infested Christmas trees into Georgia and North Carolina were reported.

Slow The Spread Project (STSP) participation was reported in North Carolina in nine northeastern counties. STSP Project was initiated in 1992 by the

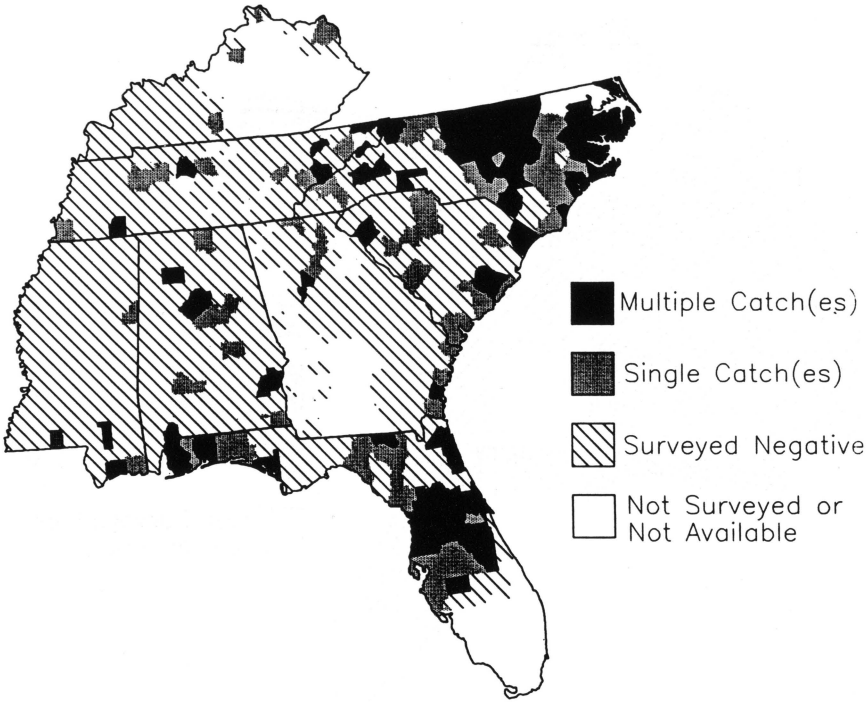

Fig. 4. Results of 1992 gypsy moth detection pheromone trap surveys conducted in the eight southeastern states that comprise the PPQ southeastern region. Data presented are county level summarizations of all detection survey traps operated in the respective counties by all agencies.

U.S. Forest Service as a successor to the Appalachian Integrated Pest Management (AIPM) gypsy moth program (USDA 1989). The overall STSP project goal is "to determine the feasibility of using Integrated Pest Management strategies to slow the spread of gypsy moth over a large geographical area" (Swain and Wolfe 1993). Pesticides were applied to about 6804 hectares (16,800 acres) in three states in the region for GM control/eradication in 1992. Two thousand six hectares (5200 acres) were treated with aerially applied *Bacillus thuringiensis* (*Bt*) in Georgia. Approximately 3483 hectares (8600 acres) were treated in North Carolina and about 1215 hectares (3000 acres) were treated in Tennessee. The NC treatments were made in 10 counties: 5 sites [about 12.1 hectares (30 acres)] were treated by ground application methods and 7 sites consisting of approximately 3482 hectares (8600 acres) were treated by air. Four hectares (10 acres) of the aerially-treated area in NC received additional treatments by ground application methods. Approximately 227 hectares (560 acres) were treated with diflubenzuron (Dimilin®, Uniroyal Chemical Company, Inc.); *Bt* was used in the remaining NC treatments. Tennessee treated 810 hectares (2000 acres) with *Bt* and 405 hectares (1000 acres) with diflubenzuron.

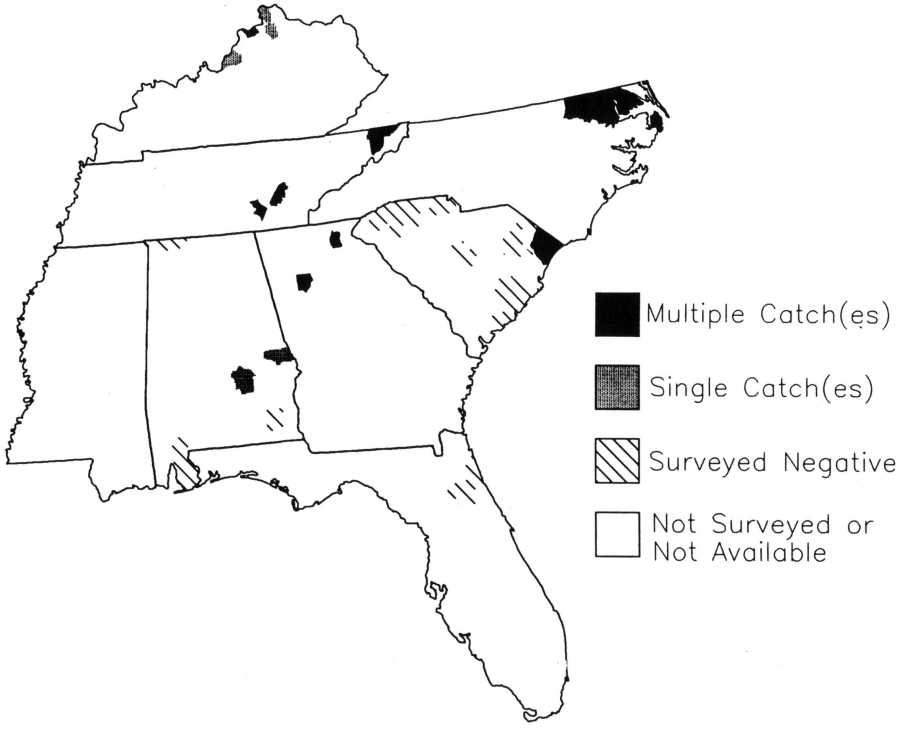

Fig. 5. Results of 1992 gypsy moth delimiting pheromone trap surveys conducted in the eight states that comprise the PPQ southeastern region. Data presented are county level summarizations of all traps operated in the respective counties by all agencies.

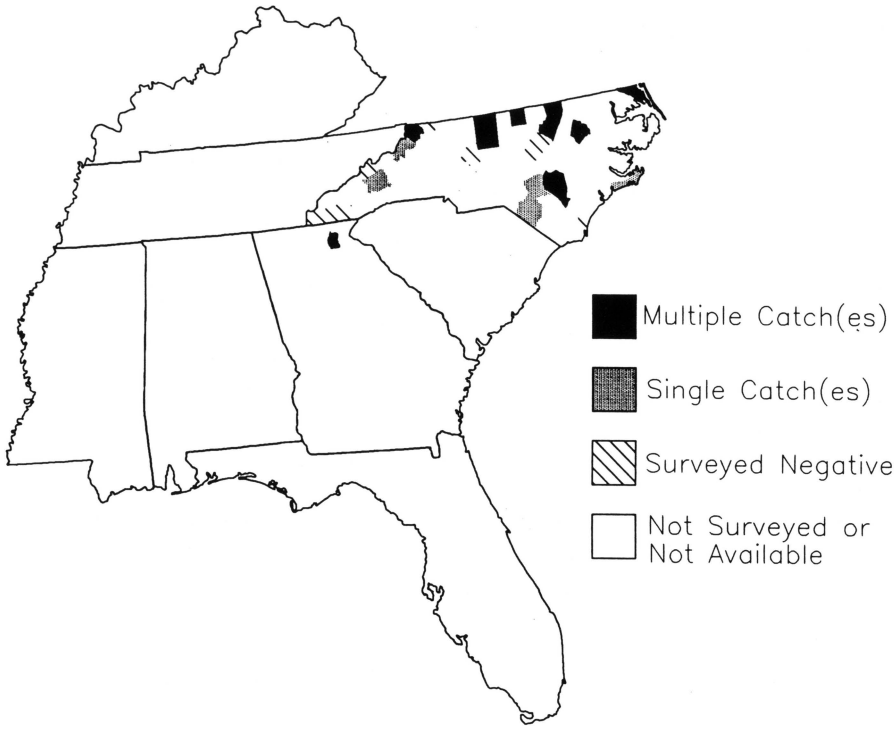

Fig. 6. Results of 1992 gypsy moth mass trapping surveys conducted in the eight states that comprise the PPQ southeastern region. Data presented are county level summarizations of all mass trapping surveys operated in the respective counties by all agencies.

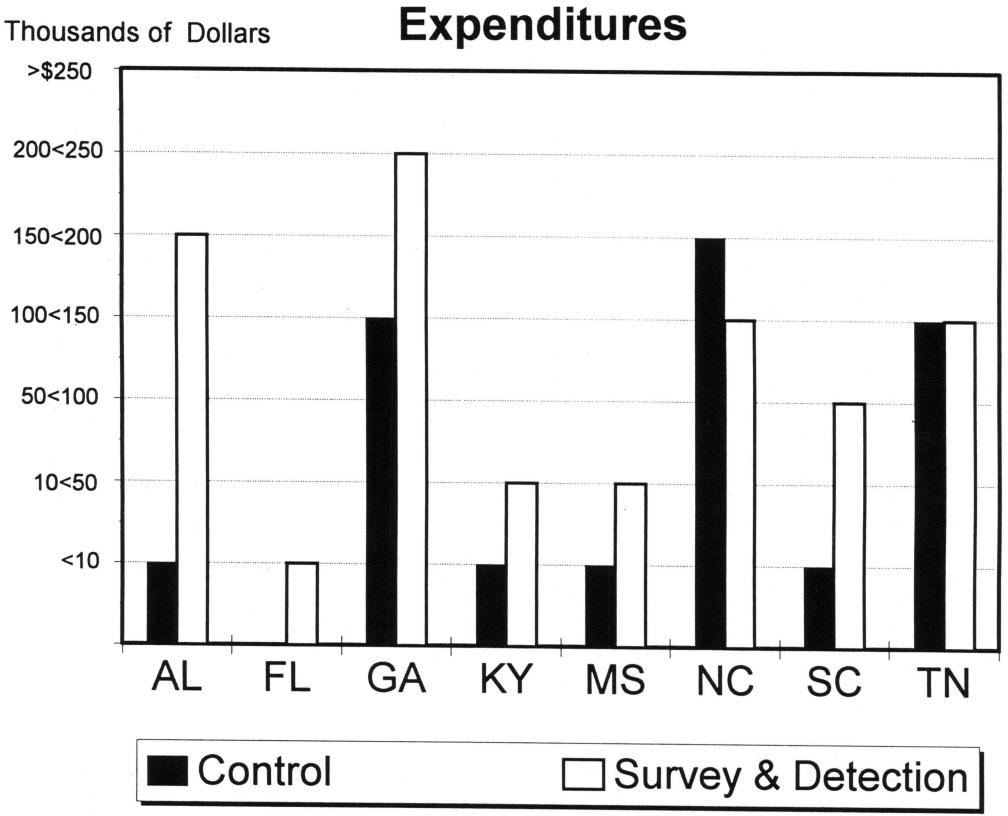

Fig. 7. 1992 expenditures for gypsy moth survey and detection, and control programs for each of the eight states in the southeastern PPQ region. Data are composite expenditure estimates for all agencies involved in the cooperative gypsy moth program.

Program Costs. Regulatory and cooperating officials in each state supplied estimates of total dollars expended in their state (as ranges) for all cooperating agencies for: Survey and Detection, Delimiting and Control Programs during the year (Fig. 7).

In excess of 31.1 million hectares (76.8 million acres) of forested land have been defoliated by gypsy moth in the United States from 1924-1993 (GMD 1993). Since 1980, gypsy moth has annually defoliated at least 0.4 million hectares (1 million acres) of forested land (McManus et al. 1989). Liebhold et al. (1991) provided projections for the natural spread of gypsy moth based upon available quarantine records and mathematical models using available climatological data. Their projections suggested that in the Southeast, only a portion of Virginia should have been infested in 1990. When the predictions were carried forward to the year 2015 for the Southeast PPQ region, only North Carolina, Kentucky and a portion of Tennessee would be infested. However, isolated infestations have already occurred in the southeastern states of Georgia, North Carolina, Tennessee, and Arkansas as well as in California, Oregon, Utah, Washington and Wisconsin (GMD 1993). It is generally accepted that these infestations were started by transport of gypsy moth lifestages into the area by human activities.

Gypsy moth threatens forest industries, recreational areas, and homeowners in the Southeast and across the U.S. The significant numbers of gypsy moth interceptions that have occurred in recent years in the Southeast suggest that ample opportunity for the initiation of isolated gypsy moth infestations has occurred. Federal, state, and local government officials continue to attempt to prevent entry of, eradicate, or at least slow the spread and impact of this insect on forest habitats. It is important that these large, complex cooperative gypsy moth monitoring, control, eradication, and suppression projects continue. As managers and regulatory officials attempt to deal with gypsy moth, they will require adequate and timely knowledge of the dynamics of gypsy moth over areas that transcend ecosystems and state boundaries (for example, regional), in addition to their need for more localized information on gypsy moth. It is, therefore, important that appropriate, accurate, and timely tracking of these large, multi-agency, multi-state programs and activities be effected.

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