MONITORING CONEWORMS WITH PHEROMONE TRAPS: A VALUABLE PEST DETECTION PROCEDURE FOR USE IN SOUTHERN PINE SEED ORCHARDS

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Abstract.--Sticky traps baited with synthetic pheromone were used to detect the presence of the webbing coneworm, *Diaryctria disclusa* Heinrich, during 1981-1984 in southern pine seed orchards. The blister coneworm, *D. clarioralis* (Walker), and the loblolly pine coneworm, *D. merkeli* Mutuura and Munroe, were also trapped during 1982-1984. More than 80 orchards were surveyed in 1984. Trapping data indicate that outbreak populations of *D. disclusa* present during 1981 in eastern North Carolina and eastern South Carolina declined each year, while populations remained relatively stable or increased in orchards in central Georgia, Alabama and Mississippi during this same period. Trap catches of *D. nerkeli* remained high (25-49 males/trap/year) or very high (>50 males/trap/year) during 1984 in 57% of the orchards which detected high or very high catches in 1983. Trap catches of *D. clarioralis* remained relatively stable during the 3 year trapping period. Regional seasonal activities of the insects, and pest management decisions for individual orchards are discussed.

Keywords: *D. disclusa, D. merketi, D. clarioralis,* IPM, *Dioryctria.*

Several species of coneworms, *Dioryctria* spp., are considered key pests damaging cone and conelet crops in southern pine seed orchards (Ebel et al. 1980). Prior to 1981 blacklight traps were occasionally used by orchard managers to detect and monitor coneworm populations (Yates and Ebel 1975). This procedure was time consuming and accurate identifications of the various coneworm species were difficult.

The discovery (DeBarr and Berisford 1981) and the identification of the sex pheromone produced by female *D. disclusa* moths for the purpose of attracting males (Meyer et al. 1982) led to the development of a highly specific bait which could be used to monitor *D. disclusa* populations. In 1981 traps baited with synthetic sex pheromone of the webbing coneworm, *P. disclusa* were installed in 63 pine seed orchards (DeBarr et al. 1982). This survey demonstrated "the value of pheromone-baited traps as part of an integrated pest management approach to coneworm control in southern pine seed orchards."

Results of the 1981 survey and research aimed at identifying the pheromone produced by *D. clarioralis* females (Meyer et al. 1984) showed that both *D. clarioralis* and *D. merkeli* males were frequently attracted to bait with the single chemical component of the *D. disclusa* pheromone. Hanula et al. (1984a) demonstrated that traps baited with *D. disclusa* pheromone could be used to detect the presence of 3 coneworm species -- *D. disclusa, D. clarioralis* and *D. merkeli.* Because of the success of the 1981 survey and the discovery of cross attractancy, the 1982 survey was expanded to monitor populations of all three of these insect pests.

Survey cooperators in industrial, state and Federal forestry organizations are compiling historical data files for their orchards which are also being used to detect regional changes in yearly trap catches. Comparisons of trap catches from individual orchards are used to locate potential "hot spots" of activity. This information provides the orchard manager with an early warning system to indicate years and locations where coneworms are likely to cause substantial damage. Interpretations of trap catch data are also helping to define the regional flight periods and the population phenologies of the major coneworm species. This information is expected to increase the effectiveness of sprays timed to suppress adults or newly hatched larvae.

METHODS AND PROCEDURES

The coneworm survey is a cooperative effort between the USDA-Forest Service and cooperating orchards. Entomologists with Region 8, Forest Pest Management (FPM) and the Southeastern Forest Experiment Station supply cooperators with instructions, data sheets, and pheromone baits. Cooperators are responsible for obtaining, installing and checking traps. Orchard managers are also requested to submit their data to FPM for use in summaries and regional interpretations of trap catches.

Baits and Traps

Rubber septum dispensers impregnated with 100 µg of 98% pure (Z)-9-tetradecenyl acetate (Z9-14:AC) dispensed in 5 ul carbon disulfide are used as baits. A seasonal supply of baits is mailed to each cooperator. Baits are stored at below-freezing temperatures prior to use in the field. Either of two commercially available traps, the Pherocon 1C (Zoecon Corp., Palo Alto, CA) and Sentry wing trap (Albany International Corp., Needham, MA) are effective. In 1981, six traps were used in each orchard (DeBarr et al. 1982). Since then, the recommended procedure is to install 10 traps in a selected seed source at each orchard site. The traps are assembled and 1 bait is placed in the center of each trap bottom.

Trapping Procedures

Trapping locations are randomly selected on a grid drawn to overlay a map of the entire trapping area. The tallest tree in the general vicinity of each trapping location is selected (Hanula et al. 1984c). Selected trees are to be at least 90 feet apart.

Traps are placed in the top 10 feet of the tree crown (Hanula et al. 1984b). Traps are hung by running a nylon cord from the ground, through a wire loop which is attached at the designated height to a branch, and back to the ground (DeBarr et al. 1982). Both ends of the nylon cord are attached to the trap so that the trap can be raised and lowered from the ground.

The traps are checked once or twice a week. The numbers of moths of each species caught in each trap are recorded, and the moths are removed. Baits are changed the first of each month. Trap bottoms are changed as needed.

Traps are deployed in late March or early April and trapping continues through mid-November. Trapping is discontinued in late October or November when no moths are caught for 2 weeks at any trapping location. Data are submitted to FPM monthly.

Reporting and Summary Procedures

The Southern Region was divided into 3 areas based upon average daily January temperatures (Fig. 1). All cooperating orchards located below the 50° F isotherm are placed in Area I. Orchards located between the 45-50° F isotherm are in Area II. The remaining orchards are **in Area III**.

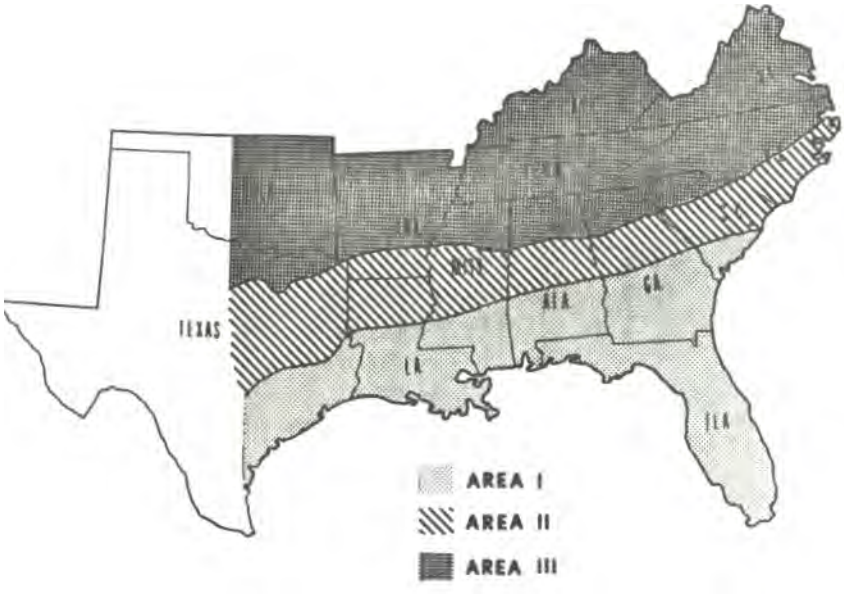

Figure 1.--Pheromone survey areas within the Southern Region.

Each cooperating orchard receives a monthly summary which ranks the total trap catch of each species for all orchards within each area. Also included in the monthly summary are 2 sets of 3 graphs. One set compares the orchard trap catch for the current year with the area trap catch for the previous year on a weekly basis. The other set of graphs compares the weekly trap catches for the orchard and the area during the current year.

RESULTS AND DISCUSSION

Interpretations of Monthly Reports

During the last week of every month each orchard manager receives a survey summary for the previous month. A case study of the trap catches at Orchard #101 illustrates how a typical monthly report might be used by a seed orchard manager in developing a pest management strategy.

Orchard #101 is located in central Alabama above the 50° F isotherm. A monthly report for Orchard #101 summarizes the trapping data from the orchard with data from other orchards within Area II. Table 1 lists the orchard rankings by total moth catch for orchards located in Area II. During the 1984 trapping season, Orchard #101 captured 105 *D. clarioralis,* 17 *D. disclusa* and 149 *D. merkeli.* While the absolute relationship between total trap catch and coneworm impact is unknown, orchard managers are encouraged to compare their data with data from other similarly managed orchards. Based on these relative comparisons, a sizeable *D. clarioralis* population was present in 1984 at

Orchard #101 and the potential for significant losses was anticipated. Trap catches of *D. disclusa* detected the presence of a minimal population in 1984 and suggested that damage during 1985 caused by *D. disclusa* should be low. Approximately 40% of the orchards located in Area II caught more *D. nerkeli* males in 1984 than did Orchard #101. However, the relatively large *D. rierkeli* trap catch (149 total) indicated that populations were present and this species should probably be considered in the pest management program.

Table 1.--Ranking by total moth catch for Orchard 101 compared to other orchards in Area II (March - November 1984)

Rank	Orchard	No. of DC	Orchard	No. of DD	Orchard	No. of DM
1	111	182	130	249	61	402
2	101	105	13	227	63	380
3	109	75	115	187	103	375
4	128	63	55	149	123	267
5	13	62	103	97	14	236
6	105	58	116	93	111	201
7	54	57	14	78	115	198
8	131	48	114	66	114	191
9	55	43	105	58	116	163
10	122	40	61	56	138	155
11	130	38	109	44	101	149
12	138	31	63	35	55	141
13	115	16	17	33	128	137
14	14	14	124	29	13	101
15	116	11	28	27	109	94
16	123	8	111	22	122	71
17	103	4	131	22	28	40
18	15	1	101	17	126	5

In addition to the ranking tables a typical monthly report contains 2 sets of graphs. One set of graphs (Fig. 2) plots the total weekly trap catches of *D. clarioralis* from all orchards located in Area II for the 1983 season. Superimposed upon the area graph is a plot of the total weekly trap catches of *D. clarioralis* from Orchard #101 for the 1984 season. This graph summarizes the seasonal flight patterns for the previous year, and by studying it the orchard manager can anticipate when current flights might begin, peak, and end. Similar graphs plotting trap catch data for *D. disclusa* and *D. nerkeli* would be included in a typical monthly report.

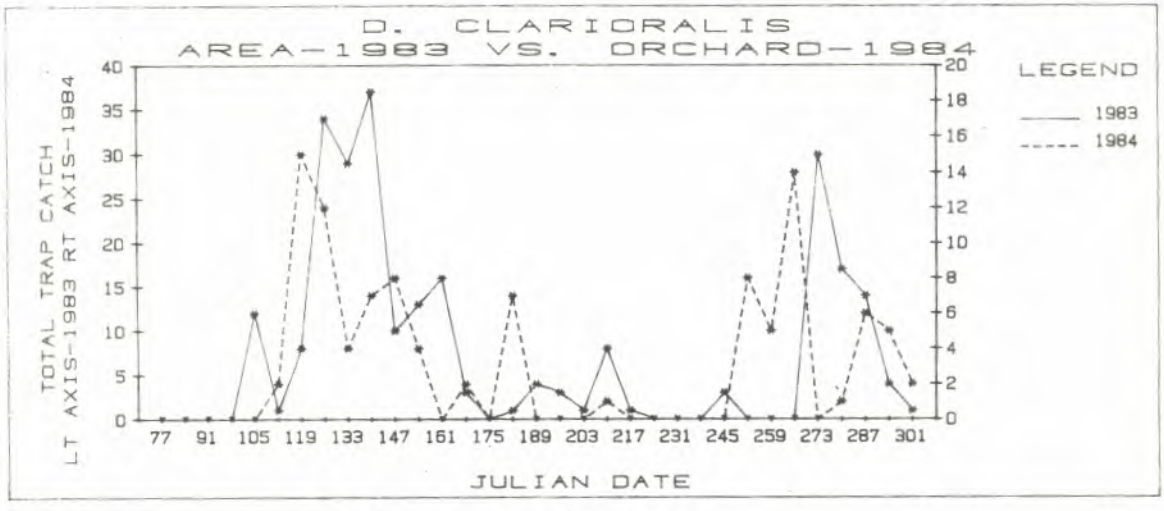

Figure 2.--Total trap catch for 1984 from Orchard #101 superimposed upon the total trap catch for all orchards in Area II which submitted data in 1983.

The other set of graphs (Fig. 3) displays the total weekly catches of *D. clarioralis* from Orchard #101 and the total weekly catches for all the orchards in Area II for the 1984 trapping season. Orchard managers can determine if the flights detected in their orchard correspond to the area flights. Similar graphs plotting the trap catch data for *D. disclusa* and *D. merkeli* would also be included in a typical monthly report.

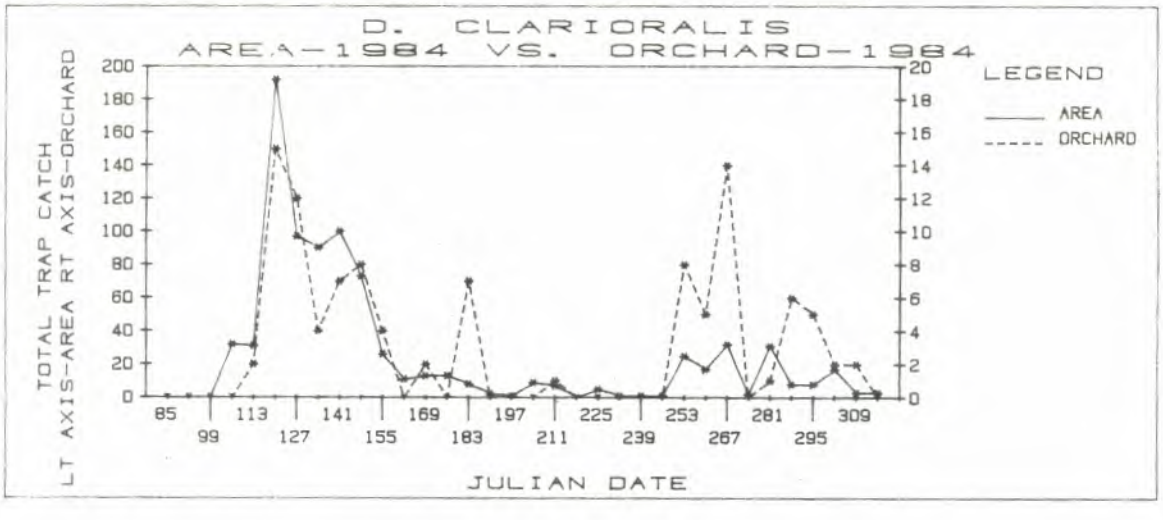

Figure 3.--Total trap catch for 1984 from Orchard #101 superimposed upon the total trap catch for 1984 from all orchards in Area II.

Pest Management Decisions Based Upon Trap Catches

Early Warning System

Seed orchard managers are using trap catches to detect the presence of *D. clarioralis, D. disclusa,* and *D. nerkeli.* The relative importance of each member of the coneworm pest complex varies by orchard and season. Although, the exact relationship between trap catch and potential damage is unknown, population trends are also evident. Table 2 lists trap catches from 2 orchards with different coneworm complexes. Trapping data from Orchard A indicate that *D. disclusa* and *D. rierkeli* are the most important pests. At Orchard B, the major coneworm is *D. clarioralis* and pest management efforts should be aimed at suppressing this species. Based upon our trapping experience and observations the following arbitrary scale of seasonal trap catches has been developed in order to rank the relative potential for cone attacks by each species: very high, >50 moths/trap; high, 25-49 moths/trap; moderate, 10-24 moths/trap; low, 1-9 moths/trap; very low, <1 moth/trap. Each season, seed orchard managers use this arbitrary scale to determine which species pose the greatest threat to next years cone crop. Management decisions are modified in order to target control actions for major pest species at each location.

Table 2.--Total trap catches for 1982-1984 at Orchard A (Perry Co., MS) and Orchard B (Geneva Co, AL)

Orchard	Year	*D. clarioralis*	*D. disclusa*	*D. merkeli*
A	1982	27	323	230
	1983	3	415	1
	1984	52	76	1
B	1982	120	4	155
	1983	227	3	21
	1983	125	0	18

In addition to identifying the coneworm complex found within each orchard, trapping data indicate population trends over time. Figure 4 illustrates two different population trends which have been detected with pheromone baited traps. Orchard C, located in Beaufort Co., NC had a *D. disclusa* outbreak which peaked in 1981. Since 1981 the trap catch has steadily declined. Using the previously described population scale, the 1984 population level can be classified as low (1-9 moths/trap). Therefore the predicted potential cone loss for 1985 should be minimal. Pest management actions designed to control *D. disclusa* in 1985 are probably not necessary. Orchard D, located in Putnam Go., GA has also had a population outbreak of *D. disclusa;* however trap catches have remained high (25-49 moths/trap) or very high (>50 moths/trap) during the last 5 years. Trap catches indicate a steady increase from 1982-1984. Therefore, pest management actions targeted for *D. disclusa* are advisable at Orchard D.

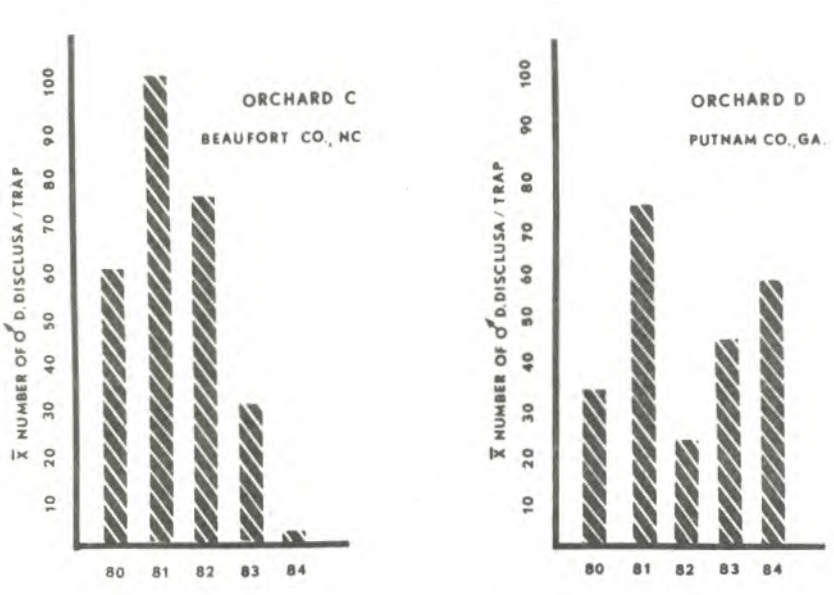

Figure 4.--Mean numbers of male *D. disclusa* per trap captured during 1980-84 in two loblolly pine seed orchards.

Seasonal Activity

Coneworm development and population phenologies are controlled predominantly by temperature accumulations (Hanula 1984b). Temperature accumulations vary at each orchard and, as a result, moth flights often begin, peak and end on different dates at different trapping locations. Peak trap catches for *D. disclusa* in the more northern orchards are 3 to 4 weeks later than the most southern orchards(Fig. 5). Figure 6 is a graph of weekly total trap catches of *D. disclusa* at 3 different orchards. Orchard E is located in Washington Parish, LA (Area I); Orchard F is located in Webster Parish, LA (Area II); and Orchard G is located in Murray Co., GA (Area III). In 1984, flights of *D. disclusa* males began on Julian dates 141, 162, and 169 at Orchard E (Area I), Orchard F (Area II), and Orchard C (Area III), respectively.

Figure 5.--Peak catch dates (month—day) for *Dioryctria disclusa* males during 1981 (From DeBarr et al. 1982).

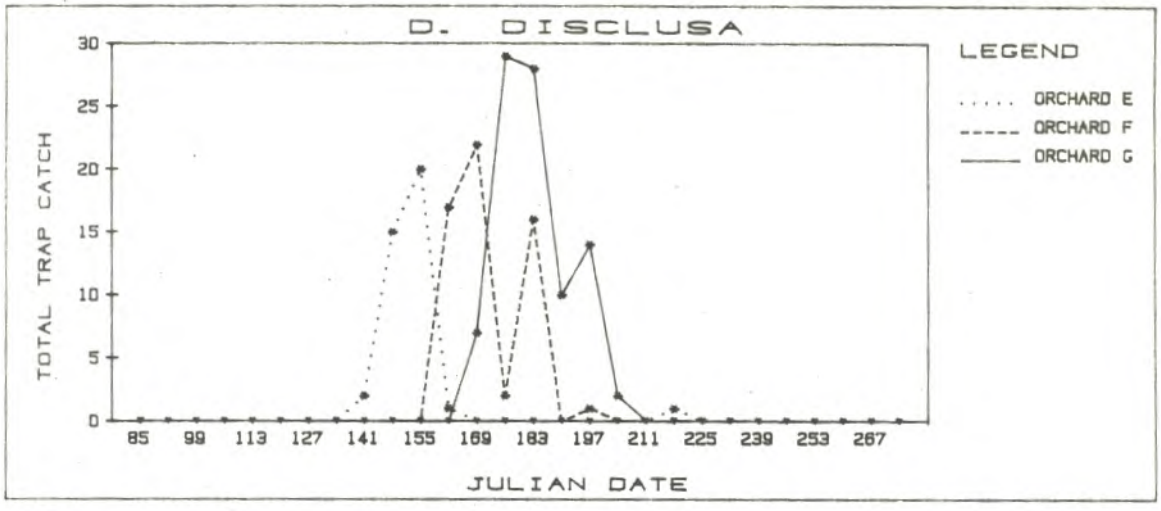

Figure 6.--Total weekly trap catchs of *D. disclusa* for 1984 at Orchards E (Area I), F (Area II), and G (Area III).

The population phenology of *D. merkeli* is also affected by temperature accumulations. Unlike *D. disclusa* which flies in late spring, *D. merkeli* flies in late summer and fall. With the onset of cooler temperatures and shorter day lengths typical of late August, September and October, adult flights of *D. merkeli* in more northern orchards occur earlier than flights in southern orchards (Fig. 7). The earlier flight is a survival mechanism which insures that adult emergence, mating and egg development occur before low temperatures prevent normal behavioral activities and development. Figure 8 is a graph of the weekly total trap catches of *D. merkeli* at 3 orchards. Orchard H. is located in Monroe Co., AL (Area I); Orchard I is located in Greene Co., AL (Area II); and Orchard J is located in King William, Co., VA (Area III). In 1984 the adult flights of *D. merkeli* began on Julian dates 267, 246, and 225 at Orchard H (Area I), Orchard I (Area II) and Orchard J **(Area** III), **respectively.**

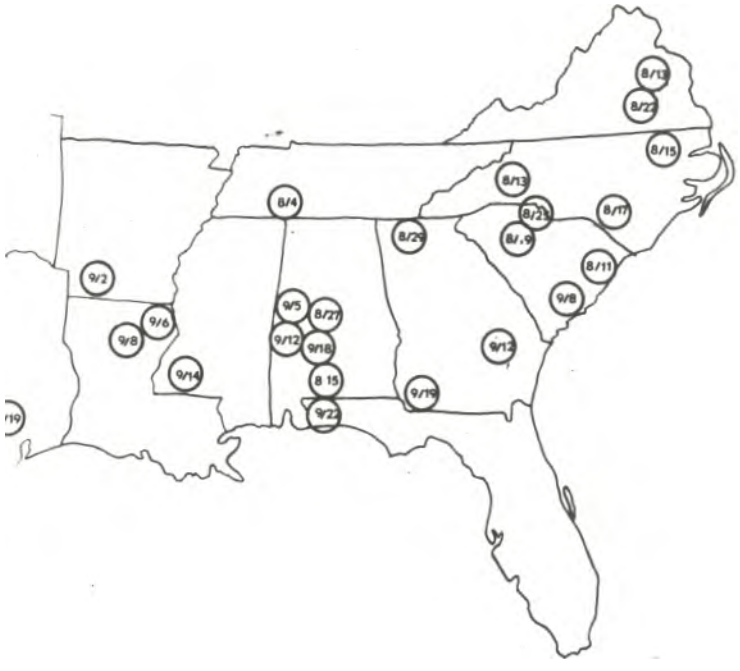

Figure 7.--First catch dates (month-day) for *Dioryctria merkeli* males during 1984 (Only orchards which caught 50 or more males/season and trapped through Julian day 270 are included).

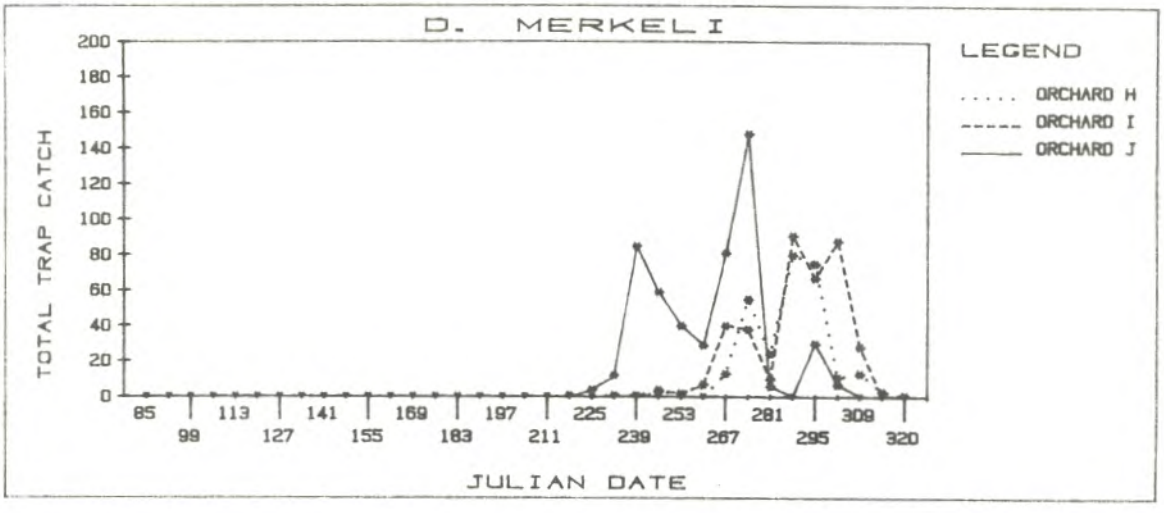

Figure 8.--Total weekly trap catches of *D. merkeli* for 1984 at Orchards H (Area I), I (Area II), and J (Area III).

For the present, pheromone traps provide the orchard manager with local seasonal activity patterns for the major coneworm species. Research is underway to develop degree-day prediction models for use with pheromone traps. In the future, temperature accumulations will be set to coincide with the beginning of moth flight and insecticide applications will be timed for maximum effectiveness against susceptible lifestages.

Regional Interpretations

The regional population levels for the 1981-1984 *D. disciusa* survey are shown in Figure 9. Each dot on the map represents the total seasonal catch per trap for each cooperating orchard. Dot size indicates the relative population classified according to the previously described population scale. In 1981 outbreak populations were detected at several orchards along the east coast in North Carolina, South Carolina, and Georgia. By 1984, populations in this area had declined. However, "hot spots" were detected at several orchards scattered throughout the south. Figure 10 shows regional trends for orchards which increased or decreased one or more population classes. Comparisons between catches in 1982 and 1983 indicate increasing population trends in Mississippi and Alabama. A similar trend was apparent in comparisons between catches in 1983 and 1984. The majority of the orchards which trapped moderate or high populations in 1984 detected increasing population trends from levels detected in 1983. Orchard managers are encouraged to consider both the relative population size and trend when developing pest management strategies.

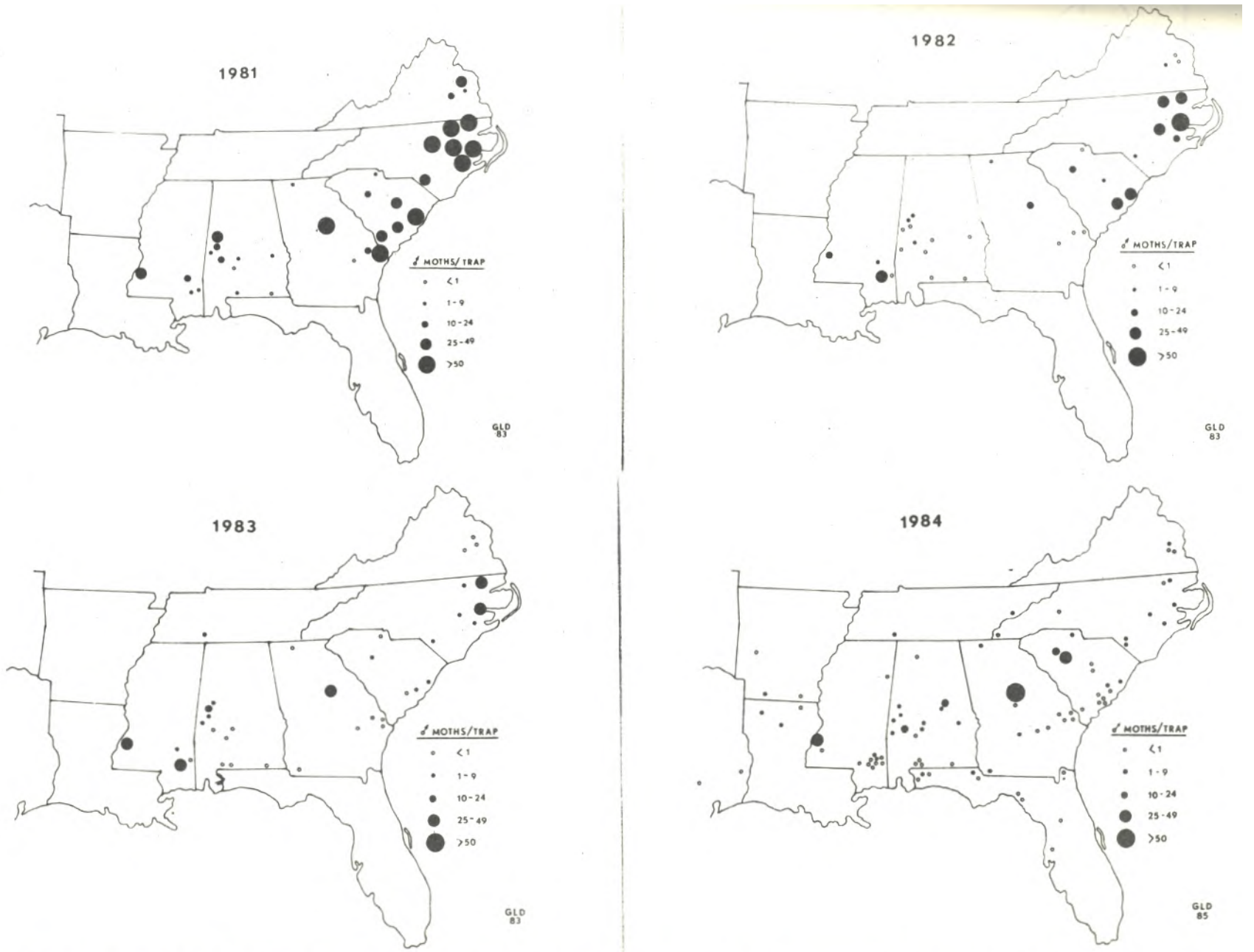

Figure 9.—Average numbers of male *D. disclusa* caught per trap for Pherocon 1C traps (N=10) baited with synthetic sex pheromone at each orchard location during 1981-1984.

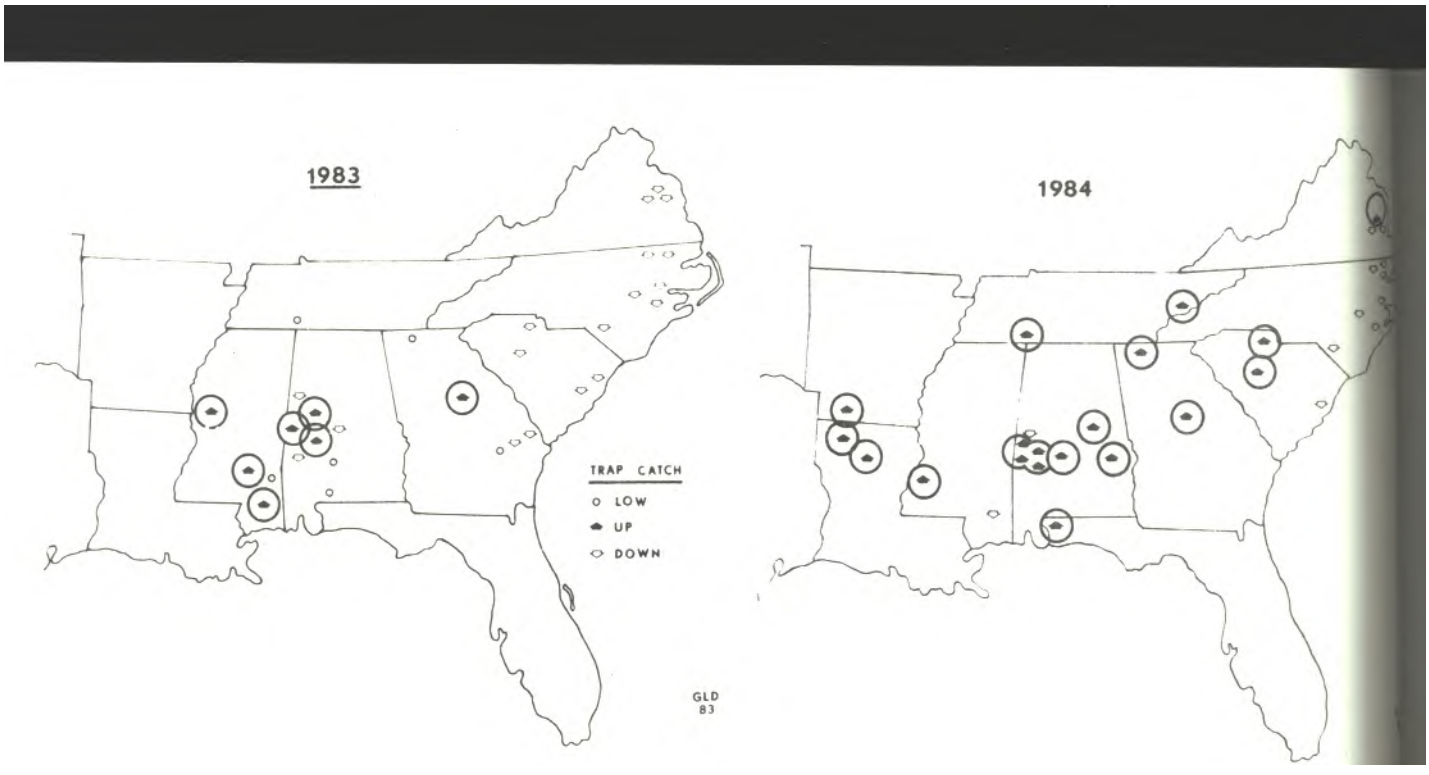

Figure 10.--Regional population trends for pheromone trap catches of *D. disculsa* from 1982 to 1983 and 1983 to 1984. (Up and down arrows reflect a change of one or more population classes).

Similar regional population maps have also been drawn for *D. merketi* and *D. clarioralis.* Catches of *D. merkeli* for orchards which trapped through Julian date 270 indicated high to very high populations in southwestern Alabama, eastern North and South Carolina, and Virginia during 1984 (Fig. 11). Scattered "hot spots" also occurred at several other locations. In contrast, only two locations had high trap catches of *D. clarioralis* during 1984 (Fig. 12).

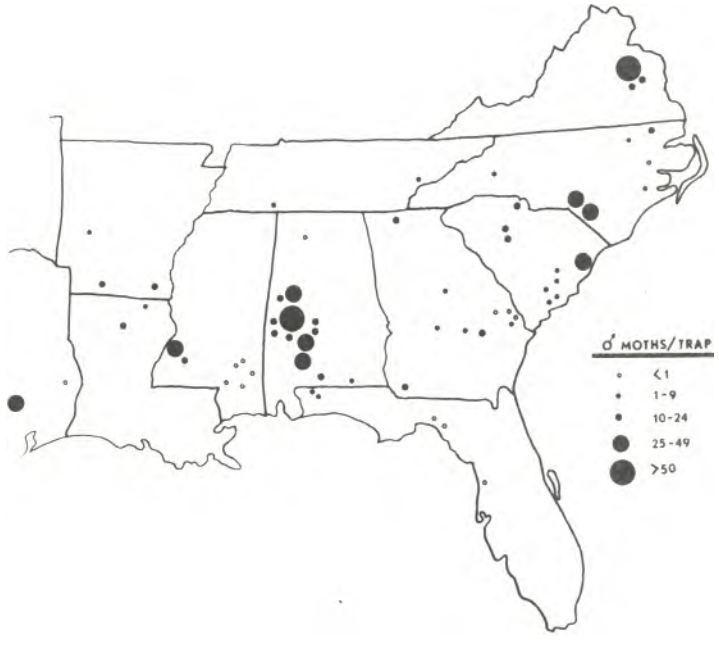

Figure 11.--Average numbers of male *D. merketi* caught per trap for Pherocon 1C traps (N=10) baited with synthetic sex pheromone at each orchard location during 1984.

Figure. 12.--Average numbers of male *D. clarioralis* caught per trap for Pherocon IC traps (N=10) baited with synthetic **sex** pheromone at each orchard location during 1984.

CONCLUSIONS

Data from the southwide coneworm survey are providing seed orchard managers, pest management specialists, and researchers with invaluable information. Orchard managers are using historical data files to make informed decisions concerning pest management strategies targeted for specific key pests. In addition, survey data are helping to define regional population trends and pest phenologies.

Efforts are being made to improve the quality of the survey data. Species identification causes confusion and occasionally errors have been detected. Incomplete data sets are fairly common particularly for fall flights of *D. clarioralis* and *D. merketi.* Orchard managers are encouraged to continue trapping throughout the fall emergence period. Research concerning trapping procedures (Hanula et al. 1984c) indicates that minor deviations from suggested procedures, particularly trap height, can cause considerable variations in trapping data. Data interpretation for individual orchards continues to be a major problem. Efforts are being made to decrease the turn-around time so that orchard managers can use current data to adjust pest management strategies.

Despite a few minor problems, the southwide coneworm survey has been an extremely successful and valuable regional effort. In the future the survey will continue to function as an early warning system, alerting seed orchard managers to potential problem species. Field tests with a synthetic pheromone for the Southern pine coneworm, *D. amaatella* (Hulst.), have been completed (Meyer et al. 1985) and baits for this species were deployed at 20 locations throughout the South. Research efforts are being directed toward gaining a better understanding of the relationship between relative trap catch and damage potential, as well as developing timing systems for insecticide applications using trapping data and temperature accumulations.

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