Comparing an IPM Pilot Program to a Traditional Cover Spray Program in Commercial Landscapes

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ABSTRACT An integrated pest management (IPM) pilot program for landscape plants was implemented during 1997 and 1998 on two commercial, two residential, and one institutional property managed by landscape professionals. When compared with preprogram, calendar-based cover spray program costs at these sites in 1996, the IPM program was cost-effective at one of the five sites in both 1997 and 1998, and cost effective at a second additional site in 1998 when the cooperator, initially skeptical of IPM, discontinued calendar-based cover sprays performed in 1996 and 1997. The mean cost per site was $703.40 (preprogram), $788.26, and $582.22 in 1996, 1997, and 1998, respectively. Volume of pesticide applied decreased a mean of 86.3% on the four sites not receiving cover sprays and increased 2.3% at site 2 (still using cover sprays) in 1997. In 1998, pesticide volume was reduced an average of 85.3% at all five sites compared with preprogram levels. The majority of insect pest problems were corrected using spot sprays of insecticidal soap or horticultural oil or by physical means such as pruning. One-third of the woody plant material on the commercial and institutional sites consisted of holly, juniper, and azalea. The most prevalent pests encountered were mites (Tetranychidae), aphids, lace bugs, scales, whiteflies, and Japanese beetle. Spiders were the most abundant group of predatory arthropod and ants, green lacewings, and lady beetles were also well represented in the managed landscapes.

KEY WORDS integrated pest management, landscape, key plant, beneficial arthropods, pesticide use, spiders

URBAN PLANTS ARE typically considered to be high value and people attach great value to their upkeep (Hartman et al. 1986). Most urban residents believe that arthropod feeding damage on landscape plants has a major impact on the quality of life (Paine et al. 1997) and they spend a large amount of money maintaining the plants' health and esthetic appearance. More than $1 billion per year is spent on commercial arboriculture for pruning, applying pesticides, and tree removal (Neely et al. 1984). Pest control is a major function of landscape maintenance firms (Garber and Bondari 1996). In 1993, 159 firms surveyed in the 20 county metropolitan Atlanta, GA, area purchased 13,210; 3,867; and 93,447 kg of active ingredients of insecticides/miticides, fungicides, and herbicides, respectively (Braman et al. 1997). Thirty-two percent of the firms surveyed in the metropolitan Atlanta area used calendar sprays to time pesticide application, whereas 55% made applications at the customer's request (Braman et al. 1997). Only 46% of the surveyed firms monitored pest populations. Cover sprays were the method-of-choice of arborists in the urban landscape in Illinois (Neely et al. 1984).

There is general agreement that public concern over pesticide use is a driving force for increased integrated pest management (IPM) adoption in urban areas (Koehler 1989). There is enough information available for arboriculture companies to begin effective IPM programs and replacing cover sprays (Nielsen 1989). In successful landscape IPM programs, control measures were implemented by either a contractor (Smith and Raupp 1986), the sponsoring arboriculture company (Holmes and Davidson 1984), the homeowner (Hellman et al. 1982, Raupp and Noland 1984), or on-campus groundskeepers (Raupp and Noland 1984), but site monitoring was done entirely by University personnel.

Large or corporate firms in the metropolitan Atlanta area are more inclined to use nonchemical control than small or independent firms (Hubbell et al. 1997) and 40% of the small firms surveyed predicted an increase in the use of pesticides in the future (Garber

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and Bondari 1996). Small firms were not as aware of the available IPM products and information as were medium and large firms. These firms requested workshops focused on IPM practices, seasonal newsletters, IPM reminders, increased public education, and "frequent on-site consultation" (Garber and Bondari 1996). Forty-six percent of these firms cite lack of information on pest biology, whereas 66 and 73% cite the lack of availability or ineffectiveness of alternatives to traditional pesticides as impediments to IPM implementation, respectively (Braman et al. 1998).

The IPM Pilot Project was designed to meet the needs of these small firms by evaluating IPM practices with a select group of landscape professionals. The objectives were to compare the costs of traditional pest management programs (calendar-based cover sprays) to an IPM program, compare pesticide use, assess the appearance of the clients' properties, determine the sites' plant composition, assess key pest and beneficial arthropod occurrence, better refine monitoring efforts, and demonstrate IPM techniques to the cooperators at their places of business for incorporation into management of their other properties. These techniques included scouting for pest and beneficial arthropods, soil sampling and fertilization, using properly-timed spot sprays directed at the pests' most vulnerable stage, using lower toxicity pesticides such as horticultural oils and insecticidal soaps, using cultural controls such as pruning, and replacing highly susceptible plants with nonsusceptible or resistant plants.

Materials and Methods

Site Selection. In 1996, County Extension Agents assisted in selecting five landscape sites located in Clayton, Coweta, Fayette, and Pike Counties in Georgia. All were established landscapes installed before 1996 and contained a high degree of plant diversity. Sites were ≈0.2–0.4 ha or possessed a readily identifiable section of similar size. Commercial, residential, and institutional sites were included to provide a range in type of client properties. All properties were managed by landscape professionals implementing calendar-based cover spray programs. Three additional sites, for a total of eight properties (two of which had received no cover sprays) were scouted for 1 yr (1998) to educate cooperators and to obtain data on pest and beneficial insect activity.

Pilot Program. Cooperators (landscape professionals) agreed to attend three training sessions, participate in a visit by University Researchers and Extension personnel to assess their site, provide pesticide records, monitor the woody ornamental plant material on the property with the scout (C.D.S.) biweekly for 45 min to 1 h, and follow the co-authors' recommendations for 2 yr (1997 and 1998). During 1997 and 1998, management recommendations (pesticide treatments, cultural, and physical controls) based on the scouting results and rule of thumb thresholds (Sparks 2000), were faxed to cooperators. The cooperator at site 2, however, continued calendar-based cover sprays in addition to making additional pesticide applications recommended by the landscape monitor (scout) in 1997. In 1998, this cooperator discontinued the cover sprays and implemented the scouting-based IPM program. The program provided training, joint-scout cooperator monitoring, management recommendations, scouting tools, a reference guide (Woodward and Sparks 2000), and pocket-sized cards for arthropod and disease identification. The landscape monitor also prepared a collection of 50+ beneficials, other nontargets, and key pests for each cooperator. Cooperators were taught to assess pest problems and evaluate control measures in 1997 and 1998. In 1999, joint scout-cooperator monitoring was discontinued and the scout served as an information resource, making occasional site visits.

Plant Composition. The location and identification (genus, species, and cultivar, when possible) of key plant material at each site was mapped. Con-specific plant material with a continuous canopy was portrayed as one plant unit (Raupp and Noland 1984).

Key Pests and Beneficial Arthropods. Woody ornamentals were sampled bi-weekly for arthropod, pathogen, or abiotic stress, and beneficial arthropods from 9 April to 27 August 1997 and 26 March to 8 September 1998. With the exception of the red imported fire ant, *Solenopsis invicta* Van Buren, turf pests and diseases were not monitored. Sampling tactics varied to accommodate the diversity of plant material. Large shrubs (>1.5 m high) at all locations and tree-form Burford hollies (*Ilex cornuta* 'canariensis' Poiret) at one commercial site (due to a dense canopy) were scouted by taking three beat samples over a 40 by 20-cm white enamel pan. One beat sample was taken from small shrubs (<1.5 m high). Magnolias (*Magnolia x soulangiana* Soulange-Bodin and *M. stellata* Siebold & Zuccarini) were scouted by performing one, 30-s foliar exam. Five, 30.5-cm branch terminals and the accompanying foliage from hemlock (*Tsuga canadensis* (L.) Carriere.) and birch (*Betula nigra* Michaux and *B. papyrifera* Marsh) were visually examined, as were three terminals from all other trees.

The first instar (crawler) is the most vulnerable scale insect stage to contact insecticides because it does not have the protective wax cover characteristic of later instars (Kosztarab 1996). Stem-infesting scale insects were monitored for crawlers by attaching double-backed sticky tape to branches near female scales or through direct observation of crawler activity. Foliar scales were brought to the lab for examination. Orton (1989) correlated scale crawler and other insect activity with temperature by subtracting a threshold temperature for insect activity from the average daily temperature. The resulting number of "growing degree-days" (GDD), a measure of accumulated "thermal units," is a more accurate method of predicting insect activity than solar calendars (Orton 1989). Growing degree-day data were estimated for crawler emergence of several scale species based on temperature data obtained from weather stations in Jonesboro, Roopville, Griffin, and Williamson, GA, located ≈9–35 km from the sites. We present scale crawler data as GDD (10°C base temperature, 1 January start date) and calendar-based data. This temperature is used in calculating GDD data by convention (Davidson and Raupp 1999, D'Eustachio and Raupp 2001). GDD data for other pest species were reported as described above.

Pesticide Use. The cooperators' pesticide use was monitored in 1997 and 1998 to determine the number of pesticide applications, volume of pesticide, use of lower toxicity compounds such as horticultural oils and insecticidal soaps, and plant material/pest(s) targeted. These data were compared with preprogram (1996) pesticide data obtained through pesticide records.

Program Costs. Pesticide costs were obtained for each formulation used. Equipment depreciation costs were determined using industry standards (Thomas and Wade 1999). The $20.76/h wage for a landscape crew chief was determined using HORT Management Version 5.0 Computer Cost Estimator for Landscape Management Services (Thomas and Wade 1999) and included cash wages, FICA, medical and life insurance, workers' compensation, retirement, and vacation using industry standards (Stewart 2000). Total labor costs also included an estimated 1-h travel time to and from each site per visit.

Table 1. Most common trees and shrubs encountered on commercial/institutional properties during the IPM Pilot Program in Georgia in 1996–1998

		% of total units (565)
Tree	Crape myrtle (*Lagerstroemia indica* L.)	6.85
	Maple (*Acer* spp.)	6.50
	Yoshino cherry (*Prunus x yedoensis* Matsumura)	5.80
	Oak (*Quercus* spp.)	5.62
	Dogwood (*Cornus florida* L., *C. kousa* Buerger ex Miquel)	5.10
	Bradford pear (*Pyrus calleryana* Decaisne)	2.81
	Magnolia x soulangiana Soulange-Bodin, *M. stellata* Siebold & Zuccarini	2.81
	Birch (*Betula nigra* Michaux and *B. papyrifera* Marsh)	2.64
	Southern waxmyrtle (*Myrica cerifera* L.), Elm (*Ulmus* spp.)	2.64
	Loblolly pine (*Pinus taeda* L.)	2.28
	Japanese zelcova (*Zelcova serrata* (Thunberg) Makino)	2.11
Shrub	Holly (*Ilex* spp.)	21.44
	Juniper (*Juniperus* spp.)	7.21
	Azalea (*Rhododendron* spp.)	5.27
	Laurel (*Prunus laurocerasus* M. J. Roem)	3.87
	Barberry (*Berberis* spp.)	2.81
	Nandina domestica Thunberg	2.11
	Privet (*Ligustrum* spp.)	1.93
	Abelia spp.	1.76
	Cotoneaster (*Cotoneaster* spp.)	0.88
	Boxwood (*Buxus* spp.), *Euonymus* spp.	0.70
Total		96.48

Results and Discussion

Plant Composition. Raupp and Noland's (1984) plant unit concept provided a representative picture of the sites. Thirty-four percent of the woody plant material at commercial and institutional sites consisted of holly (primarily *Ilex cornuta* Lindley & Paxton and *I. crenata* Thunberg cultivars), juniper (*Juniperus horizontalis* Moench, *J. davurica* Pallas, *J. chinensis* Lindley, and *J. conferta* Parlatore), and azalea (Table 1). Holly, juniper, and azalea accounted for 27% of the woody plant material on the University of Maryland campus (Raupp and Noland 1984). Nearly one-third of the woody plant material at our sites were crape myrtle (*Lagerstroemia indica* L.), maples (*Acer* spp.), Yoshino cherry (*Prunus x yedoensis* Matsumura), oak (*Quercus* spp.), and dogwood (*Cornus kousa* (Buerger ex Miquel) Hance and *C. florida* L.). At the University of Maryland, oak, maple, and dogwood accounted for 26% of the woody plant material, while crape myrtle and Yoshino cherry were not among the top 10 most abundant trees (Raupp and Noland 1984).

Key Pests and Beneficial Arthropods. More than 90 arthropod taxa were observed at the sites (Stewart 2000). Spiders were the most abundant arthropod on three of the seven sites with azaleas, the most abundant predatory arthropod on azaleas at six sites, and were the second most abundant predator at the seventh azalea site. Spiders comprised 2.6% (due to large azalea lace bug and ant populations on four plants), 38.2, 22.8, 31.9, 30.0, and 12.4% of the total arthropods detected at six sites, and 10.2% at the seventh. Spiders were the most abundant predatory arthropods on three of four sites containing junipers and comprised 33.1, 15.0, 12.5, and 1.1% of the total arthropods observed. Ants were most abundant on junipers (2.6% of the total arthropods detected) at the latter site and were associated with aphids early in the season. Spiders were the most common arthropods on boxwood on three of four sites containing boxwoods, and most abundant predators on all four comprising 49.7, 46.3, 64.6, and 4.2% of the total. They were the most common arthropod on magnolia comprising 66.0, 40.3, and 18.5% at three sites of the five sites containing magnolias, and 5.7 and 14.3% at the other two sites. Other common predators on these plants were generalists including ants (Formicidae), green lacewings (Chrysopidae), lady beetles (Coccinellidae), big-eyed bugs (Lygaeidae), and dustywings (Coniopterygidae).

Hellman et al. (1982) reported that one-third of the recommendations made on their properties were cultural in nature. In our study, many potential plant health or esthetic problems were identified and reduced or eliminated by physical means such as pruning or hand removal while scouting. These include the following: azalea and camellia leaf gall (*Exobasidium vaccinii* and *E. camelliae*), bagworm (*Thyridopteryx ephemeraeformis* Haworth), eastern tent caterpillar (*Malacosoma americanum* F.), fall armyworm egg masses (*Spodoptera frugiperda* J. E. Smith), fall webworm (*Hyphantria cunea* Drury), fireblight (*Erwinia amylovora*), various lepidopteran and sawfly larvae, pine spittlebug (*Aphrophora cribata* Walker), and small localized populations of scales.

Scale pests were abundant and included camellia scale (*Lepidosaphes camelliae* Hoke), cottony camellia

Table 2. Immature scale insects and growing degree day data (GDD) in managed landscapes in Georgia

Species	Common name	1997		1998	
		Date(s)	GDD	Date(s)	GDD
Ceroplastes spp.	Wax scale[a]	30 June to 29 July	1,942 to 2,635	3 June to 30 July	1,334 to 2,971
Fiorinia externa Ferris	Elongate hemlock scale	—	—	16 June and 30 June	1,657 and 2,087
Parthenolecanium corni Bouché	European fruit lecanium scale	7 May to 4 June	846 to 1,263	19 May to 16 June	930 to 1,657
Pulvinaria floccifera Westwood	Cottony camellia scale[a]	7 May & 17 June	846 and 1,615	19 May and 16 June	930 and 1,657
Pulvinaria acericola Walsh and Riley	Cottony maple leaf scale[a]	5 June & 14 July	1,650 and 2,498	30 July	3,090
Toumeyella liriodendri Gmelin	Tuliptree scale	15 July	2,235	—	—

—, Tree removed by property owner at the end of 1997 to prevent spread of scale to nearby poplars (*Liriodendron tulipifera* L.) and magnolias.
[a] Not a common name approved by the Entomological Society of America.

scale (*Pulvinaria floccifera* Westwood), cottony maple leaf scale (*Pulvinaria acericola* Walsh & Riley), elongate hemlock scale (*Fiorinia externa* Ferris), European fruit lecanium scale (*Parthenolecanium corni* Bouché), pine needle scale (*Chionaspis pinifoliae* Fitch), tea scale (*Fiorinia theae* Green), and wax scale (*Ceroplastes* spp.).

Cottony camellia scale (*Pulvinaria floccifera* Westwood) populations consisting of five or less adult females were detected on two sites (Table 2). Two hatching cottony maple leaf scale (*Pulvinaria acericola* Walsh & Riley) egg sacs were detected in 1997 and one was seen 1998. Elongate hemlock scale (*Fiorinia externa* Ferris) was detected on two trees in 1997 and crawlers seen in 1998. All elongate hemlock scale stages have been reported occurring during the growing season with the majority of active crawlers present in May and/or June (Stimmel 1980, Johnson and Lyon 1991). European fruit lecanium scale (*Parthenolecanium corni* Bouché) crawlers have been reported in June in the northeast United States (Kosztarab 1996). A heavy infestation of tuliptree scale (*Toumeyella liriodendri* Gmelin) was discovered on the same property in 1997 and the tree was removed soon thereafter to prevent the infestation from spreading to nearby poplars (*Liriodendron tulipifera* L.) and magnolias which it also infests (Johnson and Lyon 1991). Tuliptree scale is univoltine in the northeastern United States with crawlers present in August and September (Johnson and Lyon 1991). In the southern United States, multiple or even continuous generations can occur (Hamon and Williams 1984). Wax scale (*Ceroplastes* spp.) immatures (3–5 mm in diameter) were removed at later dates in both 1997 and 1998. Degree-day data presented here do not always reflect first occurrence in the region and may coincide with new infestations corresponding to second or later generations.

The azalea lace bug, (*Stephanitis pyrioides* Scott), the most important pest of azaleas (Neal and Douglass 1988, Braman and Pendley 1992), was scouted by beating the foliage over 40 by 20-cm white enamel pan. The majority of azalea lace bugs detected throughout the 1998 growing season were adults: 128 of 135 (94.8%), 143 of 184 (77.7%), 188 of 211 (89%), 735 of 825 (89%), 27 of 36 (75%), and one of one (100%). We suspect that we missed the first generation of emerging nymphs in both years for this very reason (Table 3). Braman et al. (1992) observed the first generation of emerging nymphs at Julian date 74 and 75 (GDD 213 above base 10.2°C) in 1989 and 1990, respectively, by removing randomly selected leaves and microscopically examining them. The key to successful control of this important pest is to kill the emerging first instars in early spring before they reach the adult stage and reproduce (Sparks 2000). A more practical early-season scouting technique is to examine the underside of leaves exhibiting the characteristic chlorosis on the upper leaf surface, and tar-like excrement on the lower leaf surface using a hand lens. Growing degree data for other key pests are presented in Table 3.

Azalea leafminer (*Caloptilia azaleella* Brants) adults were detected on azalea at a only a single site on five dates during the 2-yr study (Table 4) with a

Table 3. Activity and growing degree day data (GDD) for selected pests in managed landscapes in 1997 and 1998

Species	Common name-stage	1997		1998	
		Date(s)	GDD	Date(s)	GDD
Cotinus nitida Linnaeus	Green June beetle - adult	15 July to 12 Aug	2,235 to 2,958	30 June to 30 July	2,048 to 2,906
Hyphantria cunea Drury	Fall webworm - larva	15 July to 27 Aug	2,235 to 3,333	15 July to 27 Aug	2,530 to 3,694
Popillia japonica Newman	Japanese beetle - adult	21 May to 12 Aug	1,028 to 2,958	6 May to 30 July	650 to 2,971
Stephanitis pyrioides Scott	Azalea lace bug - adult	9 April to 27 Aug	598 to 3,333	26 Mar to 8 Sept	206 to 4,021
Stephanitis pyrioides Scott	Azalea lace bug - nymph	9 April, 23 April, 17 June–27 Aug	598, 711, 1,491 to 3,333	26 Mar to 21 Apr, 3 June to 16 June, 14 July to 8 Sept	206 to 502 1,334 to 1,657 2,498 to 4,021
Tinocallis kahawaluokalani Kirkaldy	Crapemyrtle aphid	7 May to 27 Aug	846 to 3,333	6 May to 8 Sept	648 to 4,021

Table 4. Activity and growing degree day data (GDD) for selected pests in managed landscapes in 1998

Species	Common name- stage	Dates	GDD
Caloptilia azaleella Brants	Azalea leafminer - adult	19 May; 3 June, 30 June, 14 July, 12 Aug	926, 1,317; 2,048, 2,444; 3,237
Corythucha arcuata Say	Oak lace bug - adult	19 May to 3 June, 30 June, 30 July to 8 Sept[a]	930 to 1,334; 2,087; 2,971 to 4,021
Corythucha arcuata Say	Oak lace bug - nymph	19 May to 3 June, 30 June to 30 July	930 to 1,334; 2,087 to 2,971
Malacosoma americanum Fabricius	Eastern tent caterpillar - larva	26 March to 21 April	206 to 504
Metcalfa pruinosa Say	None - adult	3 June to 8 Sept	1,334 to 4,021
Metcalfa pruinosa Say	None - nymph	21 April to 30 July	502 to 2,971
Monarthropalpus flavus Schrank	Boxwood leafminer - adult	7 April to 21 April	361 to 504

[a] Adult oak lace bugs first detected 27 Aug. 1997 (3694 GDD).

seasonal mean of 0.05 adult azalea leafminers per beat sample. Damage was minimal. In Florida, this gracillarid pest which only attacks azalea, undergoes continuous generations with peak populations in nurseries occurring January through March (Mizell, III, and Schiffhauer 1991). In Maryland, it undergoes two generations per year with adults emerging in June and August (Davidson and Raupp 1994). The numbers we encountered were too low to draw conclusions regarding its voltinism in Georgia. While considered to be a serious problem in landscapes, greenhouses, and nurseries wherever evergreen azaleas are grown (Johnson and Lyon 1991, Davidson and Raupp, 1994), our study indicates that the azalea leafminer in rarely encountered in managed landscapes in Georgia.

Boxwood leafminer (*Monarthropalpus flavus* Schrank) adults emerged from boxwoods 7 April to 21 April with peak emergence on 14 April (417 GDD). In Maryland and southeastern Pennsylvania, boxwood leafminer adults emerged in late April (352 GDD) and early May with peak emergence at 440 GDD (D'Eustachio and Raupp 2001).

Metcalfa pruinosa (Say), a flatid planthopper was a concern of a number of the cooperators and their clients, due, primarily to the white, cottony flocculence and cast skins produced. Ovipositional damage has been implicated in killing small twigs (Johnson and Lyon 1991). We saw no nonesthetic damage on any of the 15 plant taxa on which the insect was found. In addition, to the published host range (Dean and Bailey 1961, Wilson and McPherson 1981, Johnson and Lyon 1991) *M. pruinosa* nymphs and adults were observed feeding on boxwood (*Buxus* spp.), *Cotoneaster* dammeri 'Coral beauty' (C. K. Schneid), hemlock (*Tsuga canadensis* L.), crape myrtle (*Lagerstroemia indica* L.), and rose (*Rosa* spp.). Nymphs were detected in Illinois 30 May to early August, with adults present from early July to early October (Wilson and McPherson 1981). In Georgia, activity dates of both stages occurred earlier in the season (Table 4).

Pesticide Use. Insecticide/acaricide applications were made at one or more sites to control aphids, primarily crape myrtle aphid (*Tinocallis kahawaluokalani* Kirkaldy) and others; boxwood mite (*Eurytetranychus buxi* Garman), bagworm (*Thyridopteryx ephemeraeformis* Haworth), dogwood borer (*Synanthedon scitula* Harris), Japanese beetle adults (*Popillia japonica* Newman), azalea and hawthorn lace bugs (*Stephanitis pyrioides* Scott and *Corythuca cydoniae* Fitch), red imported fire ant (*Solenopsis invicta* Van Buren), sawfly larvae (Argidae) on *Hibiscus* spp., spider mites (Tetranychidae), camellia scale and wax scale (*Lepidosaphes camelliae* Hoke, and *Ceroplastes* spp.); and whitefly (Aleyrodidae). Chemical controls were implemented for the following diseases: black spot (*Diplocarpon rosae*) and powdery mildew (*Sphaerotheca pannosa* variety rosae) on rose (*Rosa* spp.), powdery mildew (*Podosphaera clandestina*) on *Spirea* spp., and shothole (*Cercospora* spp.) on laurel (*Prunus laurocerasus* M. J. Roem).

This program was successful in increasing cooperator and, to a lesser extent, client awareness of the key plants, arthropods, diseases and beneficials. Importantly, the cooperators learned what not to spray. In both 1997 and 1998, more than 70 herbivorous arthropod taxa, 20 beneficial arthropod taxa, and more than

Table 5. Comparison of amount of insecticide and fungicide used in liters and number of pesticide applications in selected Georgia urban landscapes in 1996, 1997, and 1998

Site	Type	1996 (Cover spray)		1997 (IPM)[a]		1998 (IPM)		% reduction in pesticides	
		Pesticide (liters)	No. of sprays	Pesticide (liters)	No. of sprays	Pesticide (liters)	No. of sprays	1997	1998
1	C	265.0	2	54.9	5	34.1	3	79.3	87.1
2[a]	C	1,893.9	5	1,939.4	7	90.9	4	−2.3	95.2
3	I	227.3	4	56.8	5	22.7	2	75.0	90.0
4	R	314.4	12	30.3	4	125.0	9	90.4	60.2
5	R	3,787.9	10	27.8	3	234.8	4	99.3	93.8

C, commercial property; I, institutional property; R, residential property.
[a] Cooperator continued cover sprays in 1997.

Table 6. Percentage of horticultural oils and insecticidal soaps used (by volume) at five urban landscapes

Site	Type	1996	1997 (IPM)	1998 (IPM)
1	C	0.0	100.0	100.0
2[a]	C	20.0	21.9	100.0
3	I	0.0	53.3	100.0
4	R	0.0	13.6	51.6
5	R	0.0	87.8	21.2

C, commercial property; I, institutional property; R, residential property.

[a] Cooperator continued cover sprays in 1997.

20 plant diseases were detected. Very few of these required treatment. On three sites the clients replaced or planned to replace within a year, heavily infested or highly pest prone plants when advised that high levels of pesticide inputs would be required to meet their esthetic expectations. Hellman et al. (1982) estimated that substituting resistant plants in landscapes in place of similar plants susceptible to insects and diseases would reduce pesticide use at their residential sites by 40–80%. The azalea lace bug and two-lined spittlebug, two key pests, were most effectively suppressed in landscapes designed using resistant species of woody ornamentals and turf (Braman et al. 2000).

Furthermore, a survey of Georgia homeowners revealed that 72% want to learn more about resistant plants (Varlamoff et al. 2000).

In the IPM-based program implemented in 1997 and 1998, lower volume spot sprays directed at specific pests and plant material replaced cover sprays targeting a wide range of plant material. When compared with 1996 (calendar-based cover sprays), the volume of pesticide applied in 1997 decreased a mean of 86.3% on four sites and increased 2.3% at site 2, where cover sprays continued to be used (Table 5). In 1998, all five sites eliminated cover sprays and pesticide volume was 85.3% lower than in 1996. The number of pesticide applications increased at site 1, a commercial property, during both years of the IPM program, and decreased at site 2, the other commercial property, in 1998 when the cooperator discontinued the calendar-based cover spray program (Table 5). The number of applications at site 3, an institutional property, increased initially but declined during the second year of the IPM program. Pesticide applications at the residential properties, sites 4 and 5, decreased during both years of the IPM program.

The percentage of lower toxicity pesticides (horticultural oil and insecticidal soaps) used increased in 1997 and 1998 (Table 6). The greatest increases in the percentage of lower toxicity compounds were observed on the commercial and institutional sites (sites 1–3) at which neither fungicides nor Japanese beetle control measures were required. Fungicides were applied on one residential site and were 1.2, 0, and 18.2% of the total pesticide volume applied in 1996, 1997, and 1998, respectively.

Program Costs. The IPM program was cost-effective relative to preprogram costs (1996) at one of the five sites in both 1997 and 1998, and cost effective at a second site (site 2) in 1998 when the cooperator, initially skeptical of IPM, discontinued calendar-based cover sprays performed in 1996 and 1997 (Table 7). The mean cost per site was $703.40, $788.26, and $582.22 in 1996, 1997, and 1998, respectively. Pesticide costs decreased at every site except site 2 (in 1997). Equipment costs decreased at sites 3–5 in 1997 and at all sites in 1998. Labor costs, increased at all sites but site 5.

Urban IPM programs have been performed with varying degrees of success. Hellman et al. (1982) observed that 98% of the clients were satisfied with the program but observed no immediate change in pesticide use patterns. IPM resulted in considerable savings in an urban arboriculture project in California (Olkowski et al. 1976). Pesticide use was reduced 94% on 26 residential properties in Maryland (Holmes and Davidson 1984). In a 2-yr study in three Maryland communities (Smith and Raupp 1986) pesticide use fell 87 and 79% and the communities saved 31 and 12%. The two latter programs were cost-effective despite higher labor costs.

Our IPM program was successful both at reducing pesticide use and increasing the percentage of lower toxicity compounds (soaps and oils) at all sites. It was cost-effective at two of the five sites. Labor accounted for 79.5% of the costs of the calendar-based cover spray program in 1996. Excluding site 2 from the 1997 analysis, since the cooperator continued his cover spray program in 1997, labor, predominately scouting time, accounted for 98.6% and 98.2% of the cost of the IPM program in 1997 and 1998, respectively. Further research needs to include the development of techniques which will allow landscape managers to scout more effectively and reduce labor costs without ad-

Table 7. Pesticide, equipment, and labor costs of the 1996 cover spray and 1997/1998 IPM programs in an IPM Pilot Program for landscape professionals

Site	1996 (Cover spray)				1997 (IPM)[a]				1998 (IPM)			
	Pesticides	Equipment	Labor	Total	Pesticides	Equipment	Labor	Total	Pesticides	Equipment	Labor	Total
1	$31	$8	$213	$252	$8	$13	$783	$804	$5	$0.4	$568	$573
2[a]	$330	$86	$617	$1,033	$333	$88	$1,137	$1,558	$7	$3	$558	$568
3	$9	$7	$242	$258	$2	$2	$535	$539	$5	$0.6	$548	$554
4	$28	$14	$172	$214	$3	$1	$514	$518	$14	$12	$656	$682
5	$354	$173	$1,233	$1,760	$8	$1	$514	$523	$5	$5	$526	$536
Sum	$752	$288	$2,477	$3,517	$354	$105	$3,483	$3,942	$36	$21	$2,856	$2,913

[a] Cooperator continued cover sprays in 1997.

versely affecting esthetics. The development and increased use of plants resistant or less-susceptible to key pests may decrease the amount of plant material requiring regular scouting. Increasing the structural complexity of landscapes should result in greater numbers of beneficial arthropods and fewer pest outbreaks (Leddy (Shrewsbury) 1996, Shrewsbury and Raupp 2000). More research relating the vulnerable stage of key pests to growing degree-days, combined with growing degree-day alerts will assist in further focusing scouting efforts. Lack of esthetic injury thresholds limit the adoption of IPM in the landscape (Potter 1986, Raupp et al. 1988, Klingeman et al. 2000). The impact of beneficial arthropods, especially spiders, on these injury thresholds needs to be determined and incorporated into easy to use guidelines that will allow a scout to accurately and quickly assess the potential impact of a given pest population. Further development and implementation of these techniques should result in more cost-effective IPM programs.

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