COSTS ASSOCIATED WITH URBAN GYPSY MOTH CONTROL BY ARBORISTS: A CASE STUDY

by Christopher D. Vaughn[1], Thomas J. Straka[1], Donald L. Ham[1], Roy L. Hedden[1], and Kevin W. Thorpe[2]

Abstract. The European gypsy moth, (*Lymantria dispar* L.) is an introduced forest pest that has significantly impacted hardwood forests and urban environments in the northeastern United States. In urban settings, homeowners allocate significant financial resources to mitigate gypsy moth damage. The objective of this study was to assess the costs of gypsy moth control-related services provided by arborists to homeowners. At present, cost information on this type of service is unavailable to urban resource managers. Urban cost data will allow for comparisons of treatment alternatives between residential and other urban situations. Cost data were obtained from two large commercial tree care companies operating in the northeastern United States. From these data, an average hourly rate of $104.70 was developed for the two companies (excluding materials). This rate was broken down into five major components: (1) labor, (2) overhead, (3) equipment, (4) mobilization, and (5) profit. Labor, overhead, and equipment costs accounted for approximately 48% of the total cost to the customer. Mobilization cost which included travel and setup time accounted for approximately 15%. The materials cost varied depending on the type of treatment chosen. Data reported in this study are limited to hydraulic application.

Introduction

Since the 1800's the introduction of exotic pests into the forests of North America has become an increasingly serious problem. These exotic organisms have altered the composition and appearance of our forested ecosystems (8). The gypsy moth (*Lymantria dispar* L.), one of the best known and destructive of these forest pests, was introduced in 1869 and since then has defoliated hardwood forest and shade trees throughout the eastern United States. Extensive efforts have been aimed at eradication and control; however, the gypsy moth continues to thrive and extend its range (2). The insect is currently distributed throughout much of the northeastern United States in an area commonly referred to as the generally infested area (GIA).

In urban situations, gypsy moth larvae generate enormous public concern. This concern is primarily due to reduced aesthetic value of trees after defoliation, the nuisance created by large numbers of insect larvae, and fear of losing highly valued shade trees (9). As a result, government agencies and private property owners spend a tremendous amount of money every year to mitigate gypsy moth damage. Previous studies have focused primarily on quantifying the reduced value of urban trees (4, 6, 10). Straka et al. assessed the costs of a specialized gypsy moth management program for suburban parks (11). The focus of this study was on the treatment cost to residential property owners using hydraulic ground spray equipment. Until now, cost data on this type of service have not been available to urban resource managers.

Study Methods

A case study on cost of gypsy moth control was developed by averaging data supplied by two large commercial tree care companies. Personal interviews and phone conferences with company representatives provided general information on the types of treatment alternatives available to homeowners. Four treatment alternatives were identified, and detailed cost information was acquired for each treatment. The cost data collected in this study were from company operation centers in the area considered generally infested (GIA) with the European gypsy moth.

Two sources of cost data on spray jobs were available from both companies: (1) average cost data from all spray operations in the previous year, and (2) cost data from actual gypsy moth spray jobs in the current year. The average cost data provided the most detailed information with respect to cost components. Average cost was reported for standard size residential lots of 5,000 to 10,000 square feet with up to 10 trees having a diameter at breast height of less than 24 inches. For larger lots or more trees, a price adjustment was based on the added time requirements of the job and current demand for personnel and equipment; however, no specific guidelines exist

to make price adjustments. Gypsy moth management costs for the standard-size treatment area were broken down into six components: (1) labor, (2) overhead, (3) equipment, (4) mobilization, (5) profit, and (6) materials. Total costs reported in this study reflected the average final price per hour to the property owner.

The second data source, that from actual spray jobs, provided less detail in terms of cost components. These reports contained information on the total price, gallons of mixture applied, time spent on each job, and travel time to and from the operations center. A simple statistical analysis of the data was also performed and correlation coefficients were calculated for price, gallons, travel time, and gallons per minute. Other expressions of variability were also included such as price ranges and standard deviations.

Treatment Alternatives. Four types of insecticide treatments were considered in this study. Application of pesticide was by hydraulic ground spray equipment and treatments were as follows: (1) carbaryl (Rockland Sevin SL, 4F, 4 lbs. carbaryl/gal.), (2) *Bacillus thuringiensis (Foray 48 B - 48 BIU/gal.)*-low rate of 1.5 quarts per 100 gallons (375 ml per 100 l) of water, (3) *Bacillus thuringiensis*-high rate of 2 quarts per 100 gallons (500 ml per 100 l) of water, and (4) diflubenzuron. The first treatment used carbaryl, a broad-spectrum chemical insecticide, applied to runoff at a rate of 1 quart per 100 gallons (250 ml per 100 l) of water. An additive (molasses) was also included to act as a sticking agent. The primary advantages of this treatment were that it (1) required only one application, (2) killed all ages of larvae, (3) was less expensive when compared most to other treatments, and (4) killed shortly after contact (initial "knock-down" effect). In general, residential customers preferred treatments that produced the quickest noticeable results; therefore, sometimes preferring carbaryl to other treatments. One disadvantage of carbaryl was that it affected non-target species; however, the directed nature of applications from ground equipment minimized this effect.

The second material used, *Bacillus thuringiensis* (B.t.), is a naturally occurring soil bacterium that is pathogenic to many Lepidoptera larvae. The lower rate of B.t. was recommended for only first and second instar gypsy moth larvae, whereas the higher rate was recommended for third instar larvae. For fourth instar or larger larvae, another type of treatment was recommended. B.t. had the advantage of being far less toxic to most non-target organisms. Since B.t. was most effective against early instar larvae, an obvious disadvantage was the limited window of opportunity for treatment. The most significant disadvantage of B.t. applications was the cost of two successive treatments. Other disadvantages of B.t. included its slow mode of action, its minimal knock-down effect, its need to be ingested, and its requirement for good coverage (3).

The third material used by cooperators in this study was diflubenzuron (Dimilin™). Diflubenzuron belongs to the group of insecticides known as insect growth regulators. This one disrupts the molting process (12). Treatments were applied to runoff at a rate of 3 ounces of wettable powder per 100 gallons (23 ml per 100 l) of water. The primary advantage of diflubenzuron was that it was effective for all larval stages. Thus, the timing of application was less critical as compared to B.t. treatments. One disadvantage was that diflubenzuron cannot be used around aquatic areas (12).

Pricing Urban Pest Management Jobs. Most often urban pest control services apply pesticides from the ground rather than from aircraft or elevated platforms. Tree and landscape situations for each residence must be evaluated before an accurate price can be quoted and services rendered (1). Evaluation ensures that a competitive price is given to the customer. Thus, an understanding of how tree-care jobs are priced is prerequisite to evaluating the costs of these services.

The first step in estimating a tree care job is identifying the pest problem. The salesperson must also estimate the number of hours required to treat trees on the property. The time estimate is simply based on the salesperson's past experience with similar situations. The factors

Table 1. Average hourly pest management costs for two commercial tree care companies operating in the area considered generally infested with the European gypsy moth.

Cost Component	Sub-total	Total Cost[1]
Labor Cost		
Direct Cost		
Wages	$ 13.14	
Indirect Costs		
Payroll Taxes	$ 2.05	
Benefits + Other Indirect Costs	$ 4.37	
Total Labor Cost		$ 19.56
Administrative Overhead Cost		$ 23.51
Equipment Cost		
Combined Direct And Indirect Costs		
Standard Truck	$ 4.81	
Hydraulic Sprayer	$ 2.74	
Total Equipment Cost		$ 7.55
Mobilization Cost (travel and job set-up time)		$ 15.28
Total Pest Management Cost		$ 65.90
Average Hourly Rate (total cost + ave. profit)[2]		$104.70

[1] Costs based on an average size residence of 5,000 to 10,000 ft^2 with up to 10 trees DBH < 24 inches.
[2] Rate does not include materials cost; materials cost must be added to obtain the final price to the customer.

which influence this estimate include: (1) number and size of trees, (2) size of property, (3) physical layout of the property, (4) proximity of the property to sensitive areas, and (5) travel time to and from each job site. Travel time is accounted for by using an estimate of the average travel time for the area, and service routes are usually scheduled to minimize total travel time. The final price may be adjusted to compete with other companies in the area, to keep work crews busy when business is slow, or to select only the most profitable jobs during the busy season (1).

Cost Components. Costs of residential pest management services rendered by companies cooperating in this study consisted of six basic components: (1) labor, (2) overhead, (3) equipment, (4) mobilization, including job set-up and travel time, (5) pre-tax profit, and (6) materials (Table 1). All values were based on a hydraulic pesticide application for the standard size residential lot described earlier.

Average labor, overhead, and equipment costs were calculated by dividing the total cost in each category by the total number of hours over the time period evaluated. Mobilization cost was then derived as a fixed percentage of these three average costs. Profit was simply a stated level of mark-up based on labor, overhead, equipment, and mobilization costs. These five components determine the average hourly rate for residential pest management services. A minimum charge was assessed on all pest management jobs to account for the fixed costs associated with company operations. Also, a significant portion of the time requirements of each job was not actually spent on the job site, but in tasks like equipment preparation and travel. As a general rule, a minimum time estimate of one half hour was assessed on all pest management jobs. The cost of materials, which varied depending on the treatment alternative chosen, was then be added to obtain the final price of a particular job.

The labor cost included both the direct cost and indirect costs of employing a spray equipment operator. In general, residential jobs rarely required more than one spray operator. The direct labor cost was simply the average wage

Table 2. Material costs and total costs by treatment for a standard size residence.

Treatment	Rate (100 gal.)	Material Cost (200 gal.)[1]	Total Cost (200 gal.)[2]	Total Cost (One Treatment Cycle)[3]
Carbaryl	1.0 qt.	$ 9.70	$114.40	$114.58
B.t.-low rate	1.5 qts.	$23.40	$128.10	$256.20
B.t.-high rate	2.0 qts.	$31.20	$135.90	$271.80
Diflubenzuron	3.0 oz.	$10.99	$115.69	$115.69

[1] Cost reflects 200 gallons of mixed insecticide.
[2] Total cost includes labor, overhead, equipment, mobilization, profit, and materials.
[3] Total cost for one treatment cycle reflects two applications of B.t. and one application of carbaryl and diflubenzuron.

paid to the spray equipment operators in the area. Indirect labor costs included items such as: government taxes, benefits, personal protective equipment (boots, hard-hat, eye shield, gloves, etc...), and non-billable labor. The amount of taxes paid depended on the geographic location of the territory and the wage rate of the operator. Since the tax costs presented here were averages from several states, final figures closely approximated costs for most areas where the gypsy moth is currently distributed. Non-billable labor consisted of those costs which could not be directly billed to the customer. These costs included factors such as preparation time in the morning (filling and mixing spray tanks, fueling spray trucks), maintenance on company vehicles, and non-work related activities (such as coffee and conversation). To obtain an average cost per hour for this category, the total cost of labor, direct and indirect, was divided by the amount of total billable hours from the previous year. Billable hours were defined as the total job time including travel time to and from the job in the previous year. Average labor cost for the two companies examined was $19.56 per hour.

The next cost component, overhead, included both corporate overhead and territory overhead in the previous year. Corporate overhead included items like the salaries of corporate executives, administrative assistants, office facilities and equipment, secretaries, utilities, and state and local taxes. The average overhead cost for each territory consisted of many of the same costs as corporate overhead; however, some distinct differences existed. Territory overhead also included sales costs (items like salaries and vehicles), pest scouting costs, employee training costs, and inventory costs (current stock of fuel and materials). The final average overhead cost per hour, corporate and territory, was determined in the same manner as average labor cost. Total overhead cost was divided by the total number of billable hours for pest management services in the previous year. Average overhead cost for the two companies examined was $23.51 per hour.

The average equipment cost per hour was determined by adding the direct cost of owning the equipment plus the indirect costs of operation. Total direct cost was the non-depreciated cost of the capital asset remaining in the accounting books. The indirect cost of operation included the equipment repair and maintenance costs. The amount of fuel consumed was also included in the indirect cost figure. Total equipment cost was

Table 3. Correlation matrix from spray-time report variables.

Variable	n*	Price	Gallons
Job Time	497	0.79	0.84
Gallons	497	0.85	-----
Travel Time	202	0.38	-----
Gallons/minute	202	0.32	-----

* number in sample.

divided by the total billable hours in the previous year. Average equipment cost for the two companies was $7.55 per hour.

Mobilization cost included the cost of traveling to and from each job site. Service routes were generally planned to minimize the total travel time. The mobilization cost also included the set-up and preparation time at the job site. Preparation consisted of starting the spray equipment (engine and pumps), adjusting spray equipment (pump pressure), unrolling the spray hose, putting on protective equipment, and filling out necessary paper work. If the customer was at home, additional time was spent explaining services. Total average mobilization cost per hour was derived as a set percentage of the combined labor, equipment, and overhead costs. This percentage was based on the average amount of time spent in these activities. Mobilization cost was approximately 30% of labor, overhead, and equipment costs for the two companies examined. Average mobilization cost for the two companies examined was $15.28 per hour.

An average pre-tax profit figure was calculated for the two companies (Table 1). The corporate tax rate for ordinary income was 34%, but taxes were not included in Table 1. The average hourly rate did not include materials.

Materials cost varied depending on the treatment chosen. The application rate per 100 gallons, materials cost for 200 gallons of mixture, total cost per hour, and cost for one treatment cycle are presented in Table 2. An application rate of 200 gallons per hour was used to present these costs on an hourly basis. Material costs for 200 gallons of mixture for carbaryl, B.t.-low rate, B.t.-high rate, and diflubenzuron were $9.70, $23.40, $31.20, and $10.99, respectively.

Total costs by treatment alternative for all cost components were calculated using the 200 gallon per hour rate (Table 2). Average total costs for one treatment cycle (two successive applications of B.t.) of carbaryl, B.t.-low rate, B.t.-high rate, and diflubenzuron were $114.58, $256.20, $271.80, and $115.69, respectively. A minimum material cost was not assessed by the cooperators for gypsy moth spray jobs. However, a minimum amount of work had to be scheduled to warrant mixing pesticides in the spray tank. In heavy gypsy moth outbreaks, volume requirements were usually not a problem. Applicators usually had enough stops on their routes that mixing a large volume of spray mixture was readily justifiable. Furthermore, a smaller spray truck was usually available for smaller jobs and lighter spray schedules. On an hourly basis, materials cost per hour for one treatment cycle ranged from $9.40 to $62.40. A large variation in materials cost existed because two treatments of B.t. were recommended as compared to one treatment with other pesticides.

Actual Cost Data. Cost data from actual gypsy moth spray jobs were also available, and a large sample was obtained from a single company. However, sufficient data to conduct the analysis existed for only one treatment alternative (carbaryl). Therefore, other treatments were not included. Spray time reports were obtained from an area in New York where a high level of infestation had occurred the previous year. These reports listed the type of treatment, number of gallons applied, time spent on the job, travel time, and total man hours for the day. A correlation matrix is presented in Table 3. The gallon and job time variables were highly correlated to price with coefficients of .89 and .79, respectively. Thus, gallons was found to be the best indicator of price and job size. This finding reflects the extreme variation in tree size and the high volume capabilities of urban spray equipment. In other words, two jobs that each require only 10 minutes of spray work may require considerably different spray volumes. In addition, gallons per minute and travel time were also

Table 4. Summary price statistics by five minute job time classes for 497 ground applications of the pesticide carbaryl.

Job Time Classes	n	Mean Price ($)	Std. Deviation Price ($)
10	7	62.96	17.17
15	43	81.76	24.83
20	73	80.80	30.64
25	81	95.79	47.38
30	80	112.05	65.38
35	54	111.39	57.55
40	36	146.72	82.48
45	27	153.24	88.79
50	21	187.48	68.20
55	14	242.43	161.56
60	14	232.89	152.81
65	6	221.33	124.63
70	8	179.00	53.68
75	3	140.00	89.45
80	9	285.11	206.02
>80	21	630.45	342.26

examined using a smaller sample, and coefficients were .32 and .38 respectively.

Cost Data Variability. A large amount of variation existed within the actual cost data examined in this study. Therefore, the factors which affect these costs were examined in more detail. The factors and explanations presented in this section were derived from statistical analysis, careful examination of the data, and conversations with company representatives. The simple statistical analysis is presented in Table 4. This table presents the mean price ranges and standard deviations by five minute job time classes. Data presented in this table were collected from an area of New York where there was a severe gypsy moth outbreak in 1995.

A multitude of factors affected the cost of any particular pest management job. Due to the specialized nature of urban pest management, a limited amount of equipment and trained personnel were available to provide services. At the beginning of the spray season, competition among companies for spray jobs was more intense. Thus, prices tended to be lower during this time of year. As the season progresses, more customers begin to request services and competition among tree care companies lessens. This shift in demand for spray services causes the average price of services to increase. When a gypsy moth population reaches outbreak levels, the supply of personnel and equipment can no longer meet the demand for service. In this situation, only established customers and customers willing to pay higher prices will be serviced.

Furthermore, the financial well-being of a company's target market will also have an influence on the price charged for services. Company operations tend to be located in areas where a substantial and diverse customer base exists. Company offices/crews operating in areas of established wealth tend to have higher prices than offices/crews in other areas.

Conclusion

This study provides detailed information on pest management services provided by commercial arborists to homeowners. Previous studies have focused primarily on the benefits of urban trees. Detailed cost information on urban pest management services has been previously unavailable to resource managers.

The labor cost ($19.56 per hour) included both the direct and indirect costs of employing a spray equipment operator. Depending on the size of the company, overhead costs ($23.51 per hour) could vary significantly. Average equipment cost ($7.55 per hour) varied due to the age of the equipment (non-depreciated expense), the depreciation schedule, and the quality of maintenance schedules. The mobilization cost ($15.28 per hour) component was determined by taking 30% of the average labor, overhead, and equipment costs. Material costs were highly variable depending on the treatment applied. Material cost for one complete treatment cycle (two B.t. treatments) ranged from 11.8% to 62%

of the total cost. Material costs for carbaryl, B.t.-low rate, B.t.-high rate, and diflubenzuron treatments were $9.70, $23.40, $31.20, and $10.99, respectively.

The average billing rate per hour included labor, overhead, equipment, and mobilization costs. Average cost for these four components totaled $104.70. Due to the fixed costs associated with urban pest management, a minimum charge of approximately one-half this rate (approximately $50) was assessed on any job. However, this amount is somewhat arbitrary, since specific situations may require a different approach. In many instances, the minimum charge will be significantly higher or lower than this estimate. Market forces will affect the minimum charge assessed on spray jobs. At the beginning of the season, companies bid more competitively on spray jobs to keep work crews busy. Conversely, later in the season, the minimum amount may increase as the demand for services increases. In a pronounced gypsy moth infestation, the demand for services also increases which will also increase the minimum charge.

Literature Cited

1. Abbott, R. E. and K. C. Miller. 1987. *Estimating and pricing tree care jobs.* J. Arboric. 13:118-120.
2. Doane, C. C. and M. L. McManus. 1981. The gypsy moth. Research toward integrated pest management. USDA Forest Service Tech. Bulletin 1584. 757 pp.
3. Dubois, N. R. and F. B. Lewis. 1981. *What is* Bacillus thuringiensis*?* J. Arboric. 7:233-240.
4. Dwyer, J. F., E. G. McPherson, H. W. Schroeder, and R. A. Rowntree. 1992. *Assessing the benefits and costs of the urban forest.* J. Arboric. 18:227-234.
5. Gerardi, M. H. and J. K. Grimm. 1979. The History, Biology, Damage, and Control of the Gypsy Moth. Associated University Presses Inc. Cranbury, NJ. 214 pp.
6. Jacus, P. and V. K. Smith. 1991. Measuring use and nonuse values for landscape amenities: a contingent behavior analysis of gypsy moth control. Resources for the Future Disc. Pap. QE92-07, Washington, DC. 48 pp.
7. Katovich, S. and R. Haack. 1991. Gypsy moth in the northern hardwood forest. Northern Hardwood Notes: USDA Forest Service, North Central Forest Experiment Station. 6 pp.
8. Liebhold, A. M., W. L. MacDonald, D. Bergdahl, and V. C. Mastro. 1995. Invasion by exotic forest pests: a threat to forest ecosystems. For. Sci. Monograph 30. 41(2):1-49.
9. Moeller, G. H., R. L. Marler, R. E. McCay, and W. B. White. 1977. Economic analysis of the gypsy moth problem in the Northeast III: impacts on homeowners and managers of recreational areas. USDA For. Serv. Res. Pap. NE-360. 9 pp.
10. Payne, B. R., W. B. White, R. E. McCay, and R. R. McNichols. 1973. Economic analysis of the gypsy moth problem in the Northeast II: applied to residential property. USDA For. Serv. Res. Pap. NE-285. 6 pp.
11. Straka, T. J., R. L. Ridgway, R. H. Tichenor Jr., R. L. Hedden, and J. A. King. 1997. *Cost analysis of a specialized gypsy moth management program for suburban parks.* Northern J. Appl. For. 14(1):32-39.
12. United States Department of Agriculture. 1995. Gypsy moth management in the United States: a cooperative approach. Final Environmental Impact Statement. Vol II. Chapters 1-9.

[1]Department of Forest Resources
Clemson University
Box 341003
Clemson, SC 29634-1003

[2]U.S.D.A., Agricultural Research Service
Insect Biocontrol Laboratory
Bldg. 306, Rm. 322, BARC-East
Beltsville, MD 20705-2350

Résumé. La spongieuse (*Lymantria dispar* L.) est un insecte défoliateur des forêts qui a causé des impacts sérieux sur les forêts feuillues de bois durs et en milieu urbain dans le Nord-est des États-Unis. En milieu urbain, les résidants ont consacré des ressources financières importantes pour diminuer les dommages par cette chenille. L'objectif de cette étude est d'évaluer les coûts reliés au contrôle de cet insecte par les entrepreneurs en arboriculture auprès des propriétaires privés. Les données de coûts recueillies ont été subdivisées pour permettre la comparaison des différentes alternatives entre le milieu résidentiel et les autres situations urbaines. Les données de coûts

ont été obtenues de deux importantes compagnies d'arboriculture opérant dans le Nord-est des États-Unis. À partir de ces données, un taux horaire moyen de 104,70$ US a été développé pour les deux entreprises (excluant les frais de matériel). Ce taux a été décomposé en cinq composantes majeures: (1) main-d'œuvre, (2) frais d'administration, (3) équipement, (4) frais de déplacement, et (5) profit. Les coûts de main-d'œuvre, d'administration et d'équipement ont compté pour environ 48% des coûts facturés aux consommateurs. Les frais de déplacement qui incluent le déplacement et le temps d'installation des équipements a compté pour 14% du coût global. Les coûts en matériel ont varié quant à eux en fonction du type de traitement choisi. Les données de cette étude se limitent uniquement à des applications par vaporisation hydraulique.

Zussammenfassung. Der europäische Schwammspinner (*Lymantria dispar* L.) ist ein eingeführter Forstschädling, der starke Auswirkungen auf die Hartholzwälder und urbane Forstanlagen in den nordöstlichen Vereinigten Staaten hat. In urbanen Siedlungen stellten die Grundstückseigentümer bedeutende finanzielle Resourcen zu Verfügung, um den Schaden des Schwammspinners einzudähmen. Das Objekt dieser Studie war es, die Kosten der Bekämpfung des Schwammspinners in Beziehung zu setzen mit den Leistungen, welche die Arboristen den Grundstückseigentümern bieten, um diese zu vergleichen. Diese Daten ermöglichen es, Vergleiche zwischen Behandlungsalternativen von Wohnsiedlungen und anderen urbanen Niederlassungen anzustellen. Es wurden die Kostendata von zwei großen niedergelassenen in den nordöstlichen Vereinigten Staaten operierenden Baumpflegefirmen zusammengetragen. Aus diesen Daten wurde für beide Firmen geltend ein Stundensatz von $ 104,70 ohne Material entiwickelt. Diese Rate teilt sich in fünf Hauptkomponenten: (1) Arbeitskräfte, (2) laufende Unkosten, (3) Ausrüstung, (4) Mobilmachung und Profit. Arbeitskraft, Unkosten und Ausrüstungskosten beliefen sich auf ca. 48 % der totalen Kosten für den Kunden. Die Mobilmachung, die Anfahrt und Rüstzeit beinhalten berechnete sich auf ca. 14 % der Kosten. Die Materialkosten unterschieden sich bei den unterschiedlichen Behandlungsmethoden. Die Daten dieser Studie sind beschränkt auf hydraulische Anwendungen.